US009226313B2

(12) **United States Patent**
Horiuchi et al.

(10) **Patent No.: US 9,226,313 B2**
(45) **Date of Patent: Dec. 29, 2015**

(54) **TRANSMISSION DEVICE, RECEIVING DEVICE, TRANSMISSION METHOD AND RECEIVING METHOD**

(75) Inventors: **Ayako Horiuchi**, Kanagawa (JP); **Akihiko Nishio**, Kanagawa (JP); **Yoshiko Saito**, Kanagawa (JP); **Daichi Imamura**, Kanagawa (JP)

(73) Assignee: **PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA**, Torrance, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 111 days.

(21) Appl. No.: **13/819,556**

(22) PCT Filed: **Mar. 16, 2012**

(86) PCT No.: **PCT/JP2012/001855**

§ 371 (c)(1), (2), (4) Date: **Feb. 27, 2013**

(87) PCT Pub. No.: **WO2012/132295**

PCT Pub. Date: **Oct. 4, 2012**

(65) **Prior Publication Data**

US 2013/0155996 A1 Jun. 20, 2013

(30) **Foreign Application Priority Data**

Mar. 31, 2011 (JP) 2011-077943

(51) **Int. Cl.**
H04W 72/04 (2009.01)
H04W 72/12 (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 72/1294*** (2013.01); ***H04L 5/0053*** (2013.01); ***H04W 72/0406*** (2013.01); *H04W 84/047* (2013.01)

(58) **Field of Classification Search**
CPC H04W 72/0406; H04W 72/1294; H04W 56/003; H04W 72/0493; H04W 72/1289; H04W 72/042; H04W 72/04; H04W 28/06; H04W 84/047; H04W 72/121; H04W 72/1273; H04W 72/1284; H04W 72/0413; H04L 5/14; H04L 5/0051; H04L 5/0092; H04L 5/003; H04L 5/0094; H04L 5/0035; H04L 5/0091; H04L 5/0048; H04L 5/0007; H04L 1/1861; H04L 1/1854; H04L 5/0044; H04L 5/0053–5/0057; H04B 7/155
USPC 370/329, 279, 315, 330, 328; 375/260; 455/561, 422.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0002647 A1 1/2010 Ahn et al.
2010/0067465 A1 3/2010 Miki et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101496370 A 7/2009
CN 101669304 A 3/2010
(Continued)

OTHER PUBLICATIONS

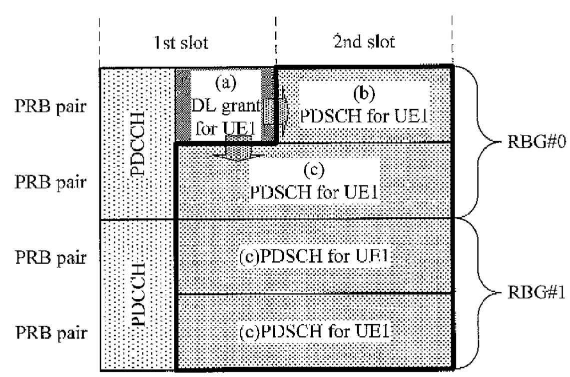
English translation of Search Report for Chinese Patent Application No. 201280002018.4 dated Aug. 24, 2015.

Primary Examiner — Marcus R Smith
Assistant Examiner — Rose Clark
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

A base station (**100**) transmits a DL grant for a terminal (**200**) by mapping it to an R-PDCCH region, thus transmitting a series of data groups to the terminal (**200**) by the SPS method. A transmission control unit (**102**) sets in the R-PDCCH region a control resource region which maps a data resource and the DL grant in a resource block group common in frames to be transmitted by the SPS method.
A resource region which was defined as a control resource region in a first frame to be transmitted among a plurality of frames to be transmitted is defined as a data resource in a second or subsequent frame to be transmitted.

16 Claims, 29 Drawing Sheets



FIRST SPS

(51) **Int. Cl.**
H04L 5/00 (2006.01)
H04W 84/04 (2009.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0044391	A1*	2/2011	Ji et al.	375/260
2011/0051681	A1*	3/2011	Ahn et al.	370/330
2011/0069637	A1*	3/2011	Liu et al.	370/254
2011/0255485	A1*	10/2011	Chen et al.	370/329
2011/0268064	A1*	11/2011	Chen et al.	370/329
2011/0274031	A1*	11/2011	Gaal et al.	370/315
2012/0039283	A1*	2/2012	Chen et al.	370/329
2012/0051270	A1*	3/2012	Chen et al.	370/279
2012/0113942	A1	5/2012	Kim	
2012/0120891	A1*	5/2012	Mazzarese et al.	370/329
2012/0207099	A1*	8/2012	Lindh et al.	370/329
2012/0320816	A1*	12/2012	Kim et al.	370/315
2013/0230015	A1*	9/2013	Hoymann et al.	370/329
2014/0219212	A1*	8/2014	Seo et al.	370/329

FOREIGN PATENT DOCUMENTS

CN	101682492	A	3/2010
WO	2008/014511	A2	1/2008
WO	2011/004989	A2	1/2011

* cited by examiner

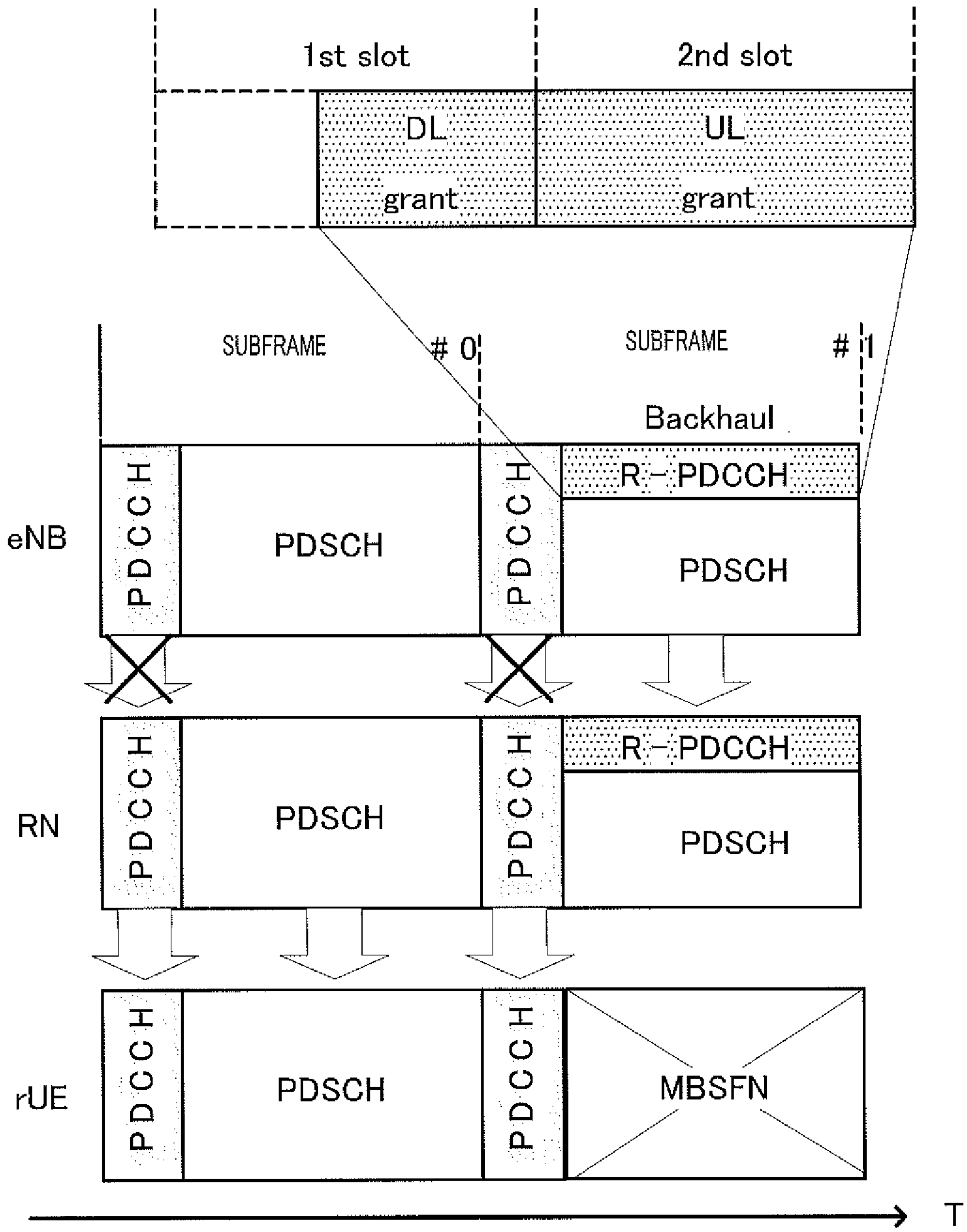
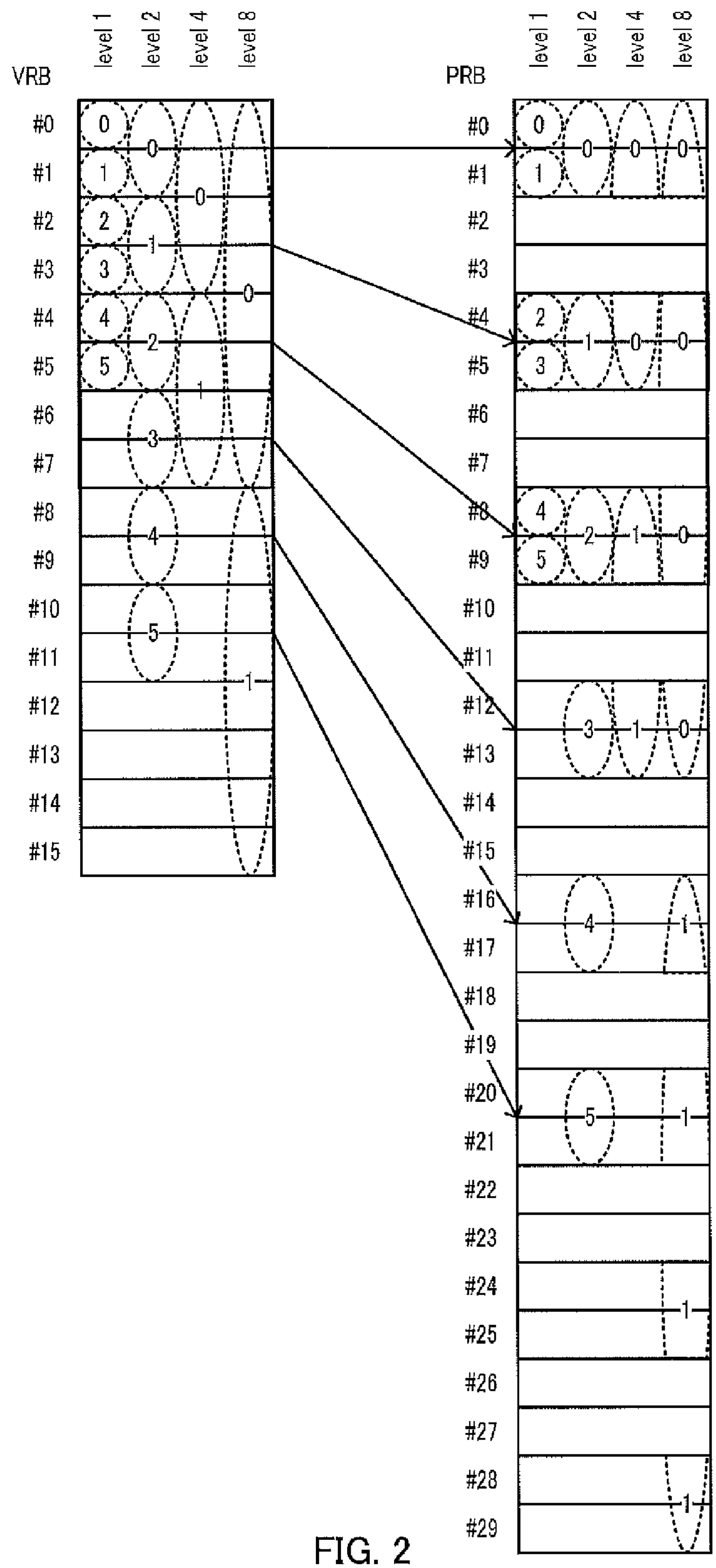

1st slot
2nd slot
DL grant
UL grant
SUBFRAME #0
SUBFRAME #1
Backhaul
R-PDCCH
PDCCH
PDSCH
eNB
RN
rUE
MBSFN
T

FIG. 1



VRB
level 1
level 2
level 4
level 8
#0
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
PRB
#16
#17
#18
#19
#20
#21
#22
#23
#24
#25
#26
#27
#28
#29

FIG. 2

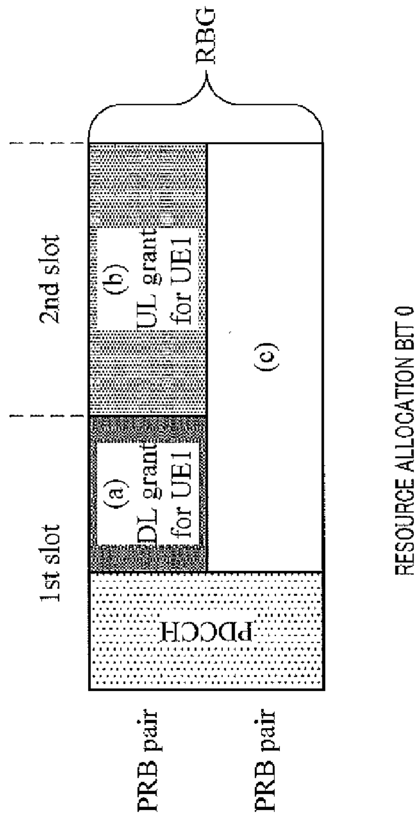

RBG
1st slot
2nd slot
PDCCH
(a)
DL grant
for UE1
(b)
UL grant
for UE1
(c)
PRB pair
PRB pair
RESOURCE ALLOCATION BIT 0

FIG. 3B

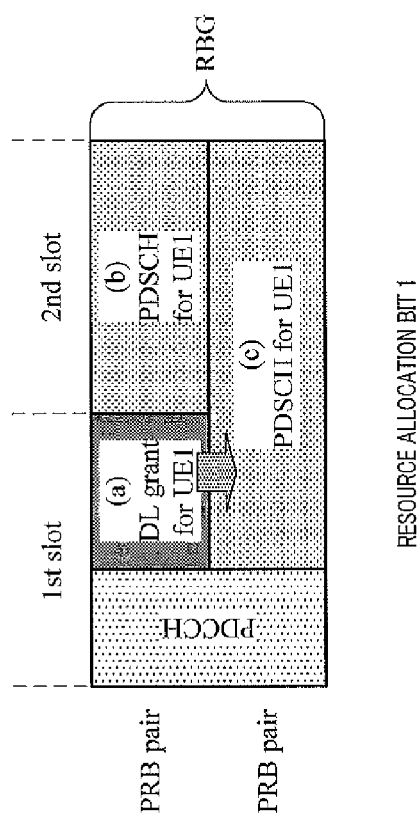

RBG
1st slot
2nd slot
PDCCH
(a)
DL grant
for UE1
(b)
PDSCH
for UE1
(c)
PDSCH for UE1
PRB pair
PRB pair
RESOURCE ALLOCATION BIT 1

FIG. 3A

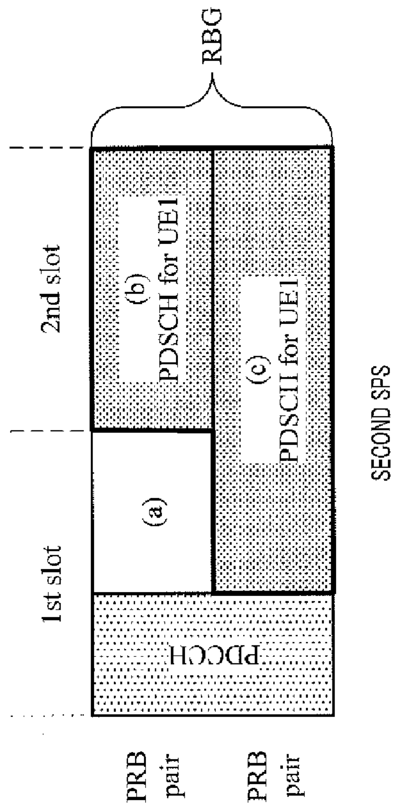

RBG
2nd slot
1st slot
(b)
PDSCH for UE1
(c)
PDSCH for UE1
(a)
PDCCH
PRB pair
PRB pair
SECOND SPS

FIG. 4B

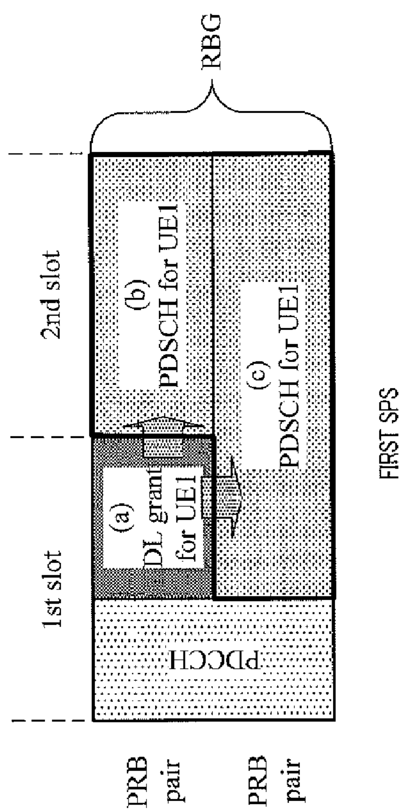

RBG
2nd slot
1st slot
(b)
PDSCH for UE1
(c)
PDSCH for UE1
(a)
DL grant
for UE1
PDCCH
PRB pair
PRB pair
FIRST SPS

FIG. 4A

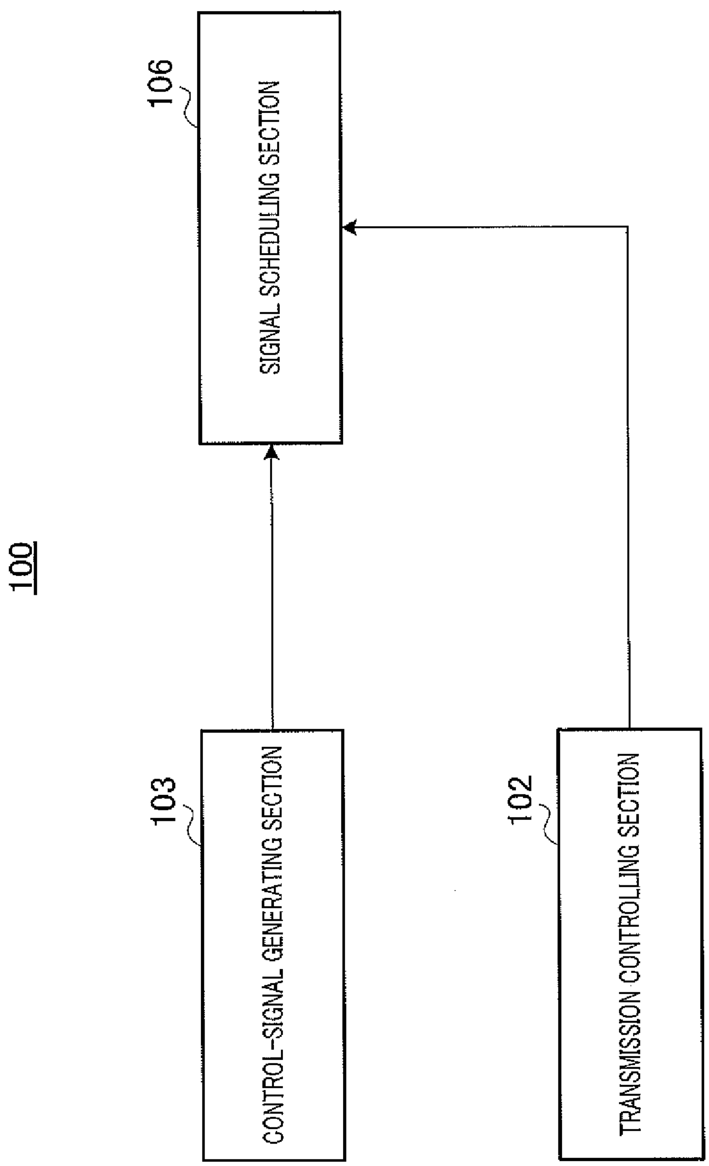

100
106
SIGNAL SCHEDULING SECTION
103
CONTROL-SIGNAL GENERATING SECTION
102
TRANSMISSION CONTROLLING SECTION

FIG. 5

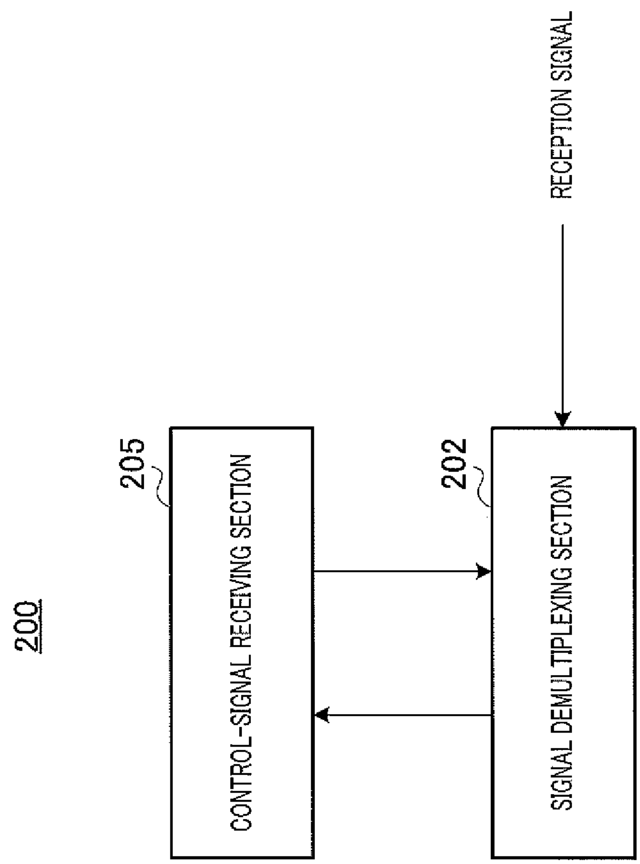

200
205
CONTROL-SIGNAL RECEIVING SECTION
202
SIGNAL DEMULTIPLEXING SECTION
RECEPTION SIGNAL

FIG. 6

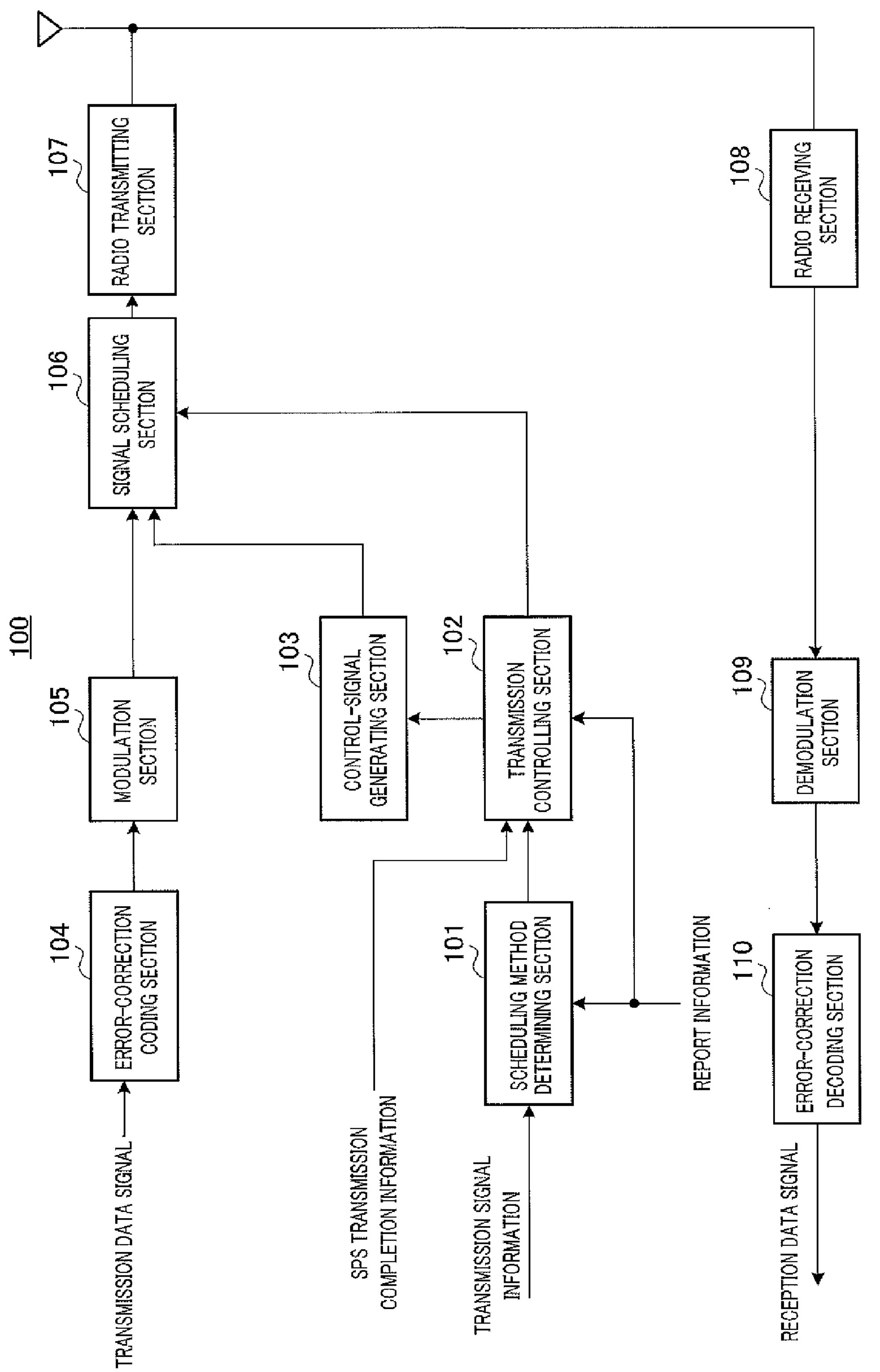

100
TRANSMISSION DATA SIGNAL
104
ERROR-CORRECTION CODING SECTION
105
MODULATION SECTION
106
SIGNAL SCHEDULING SECTION
107
RADIO TRANSMITTING SECTION
103
CONTROL-SIGNAL GENERATING SECTION
SPS TRANSMISSION COMPLETION INFORMATION
102
TRANSMISSION CONTROLLING SECTION
101
SCHEDULING METHOD DETERMINING SECTION
TRANSMISSION SIGNAL INFORMATION
REPORT INFORMATION
108
RADIO RECEIVING SECTION
109
DEMODULATION SECTION
110
ERROR-CORRECTION DECODING SECTION
RECEPTION DATA SIGNAL

FIG. 7

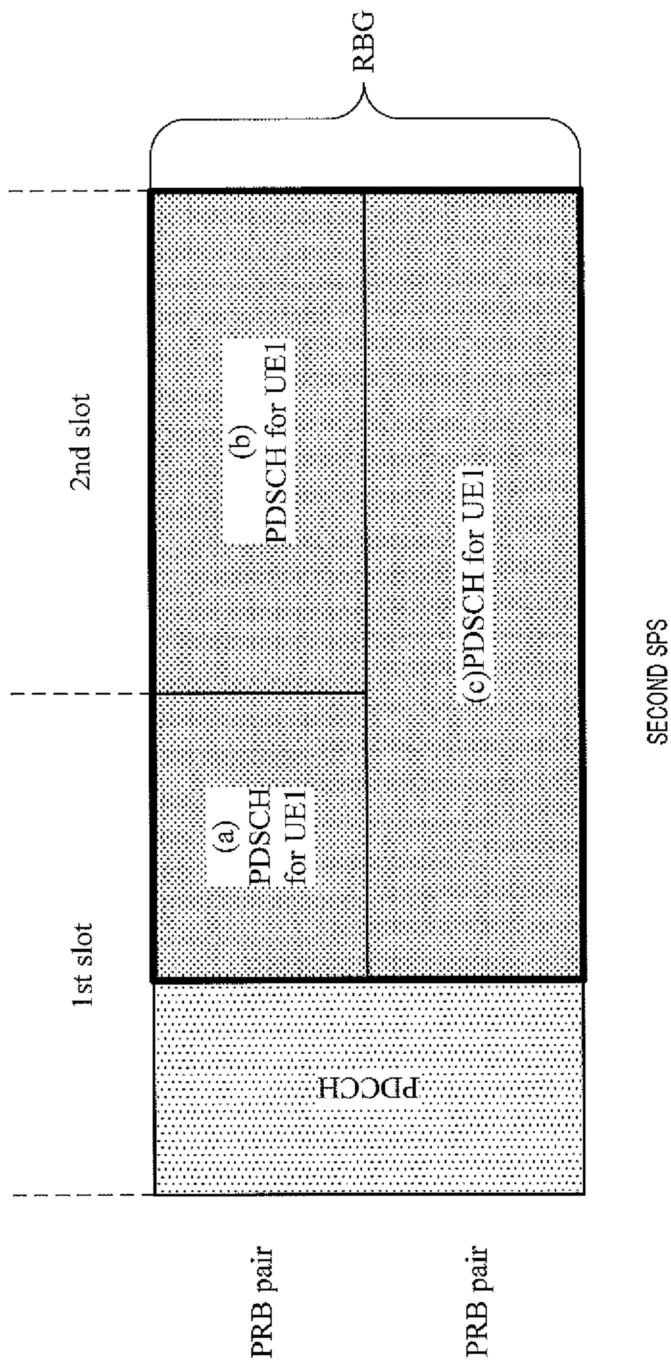
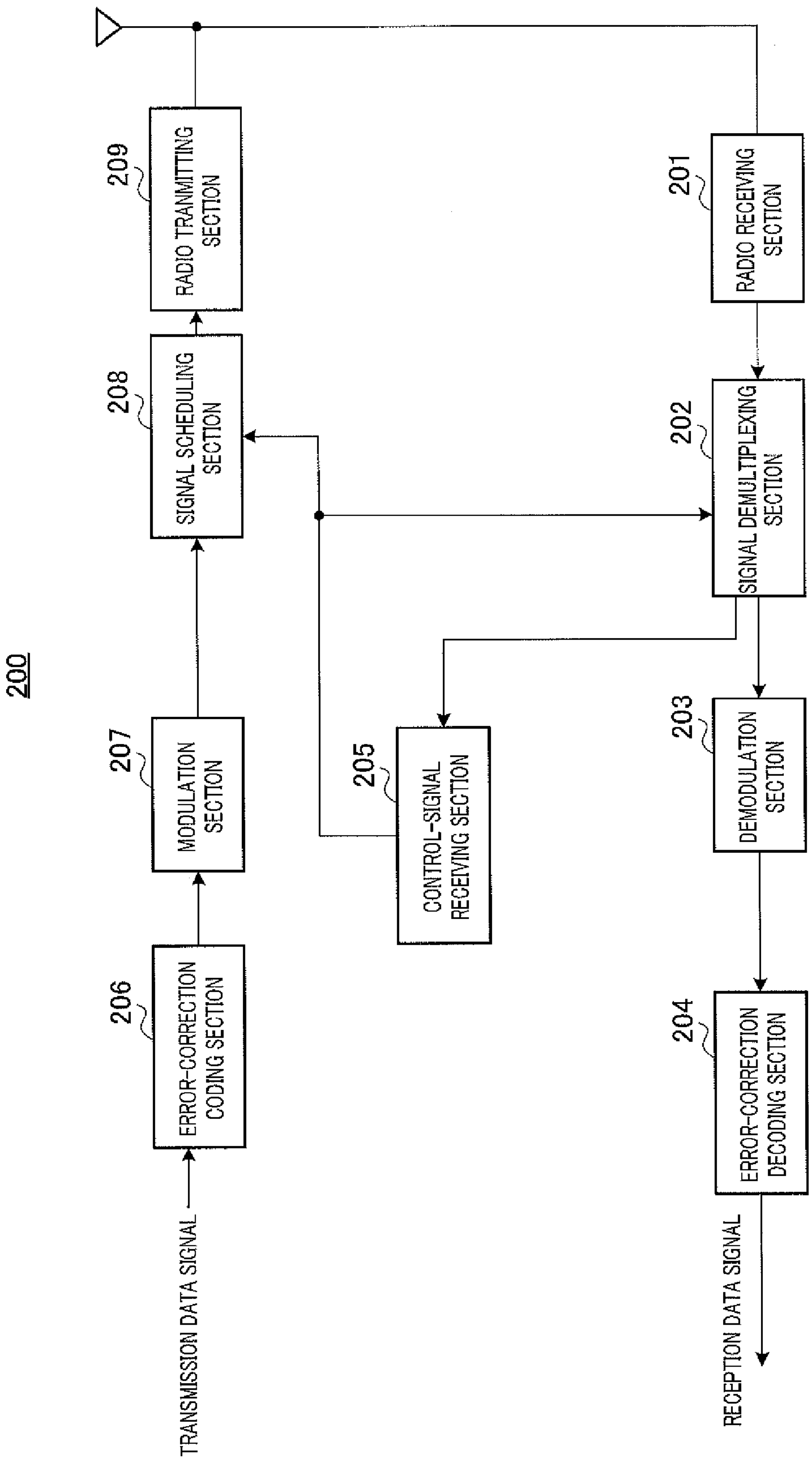

RBG
2nd slot
1st slot
(b) PDSCH for UE1
(a) PDSCH for UE1
(c)PDSCH for UE1
PDCCH
SECOND SPS
PRB pair
PRB pair

FIG. 8



200
TRANSMISSION DATA SIGNAL
206
ERROR-CORRECTION CODING SECTION
207
MODULATION SECTION
208
SIGNAL SCHEDULING SECTION
209
RADIO TRANMITTING SECTION
205
CONTROL-SIGNAL RECEIVING SECTION
201
RADIO RECEIVING SECTION
202
SIGNAL DEMULTIPLEXING SECTION
203
DEMODULATION SECTION
204
ERROR-CORRECTION DECODING SECTION
RECEPTION DATA SIGNAL

FIG. 9

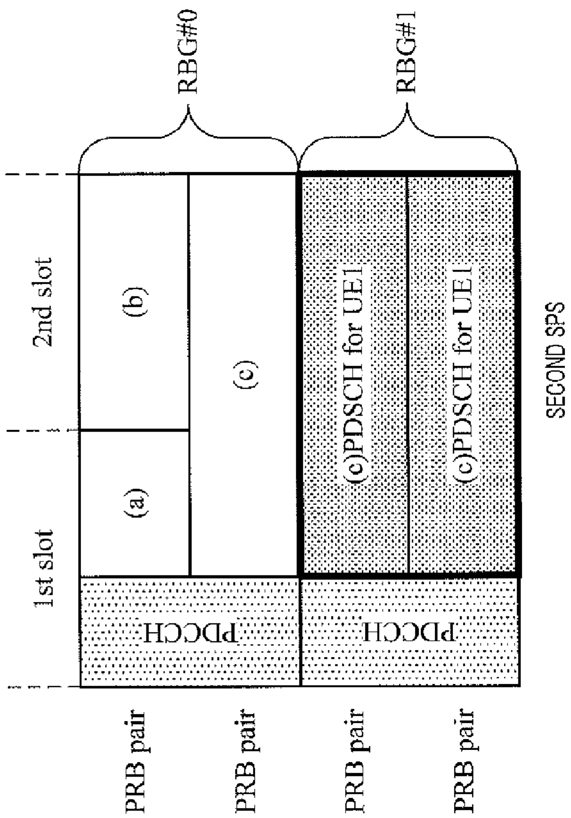


FIG. 10B

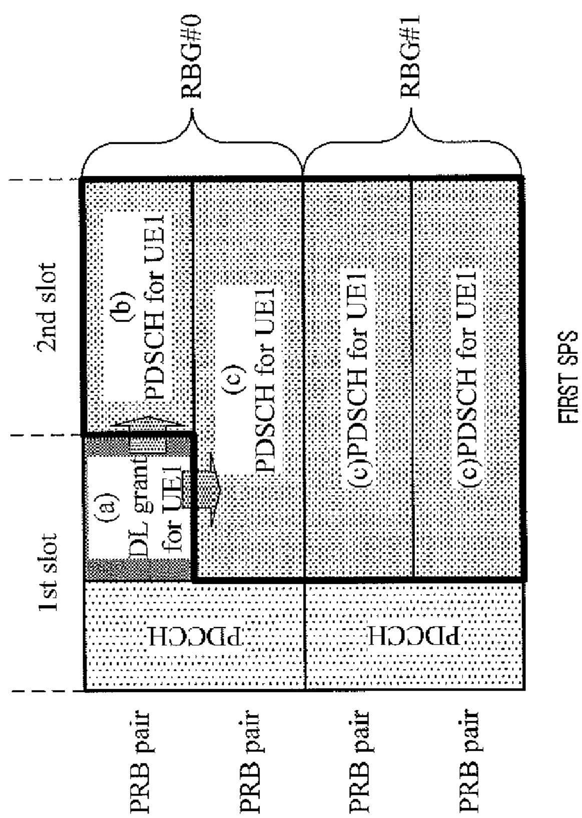
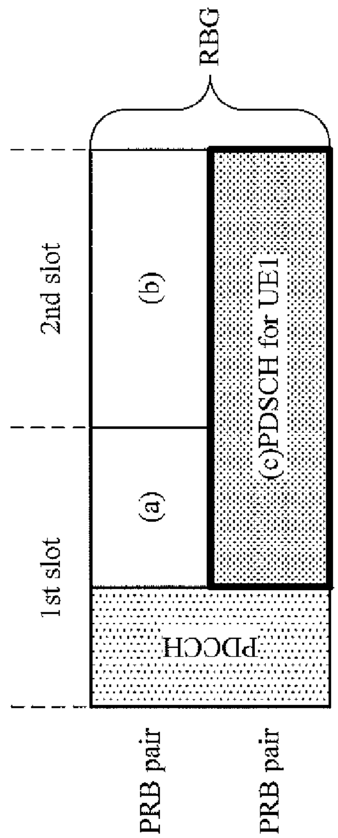
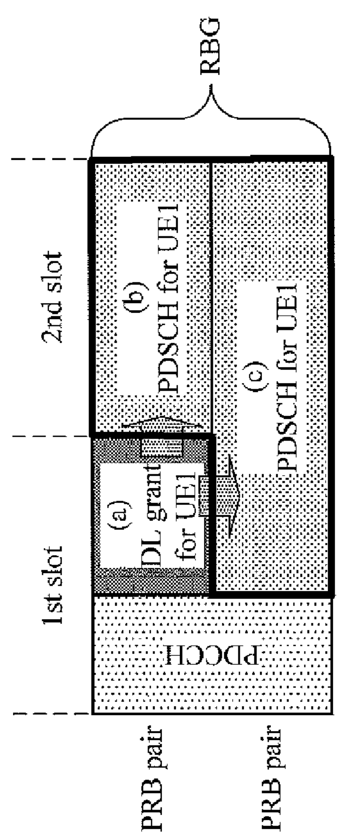


FIG. 10A



SECOND SPS

FIG. 11B



FIRST SPS

FIG. 11A

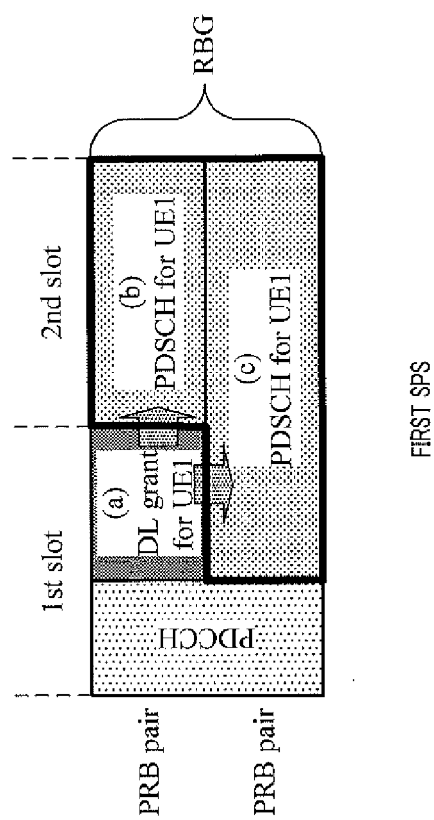


FIG. 12A

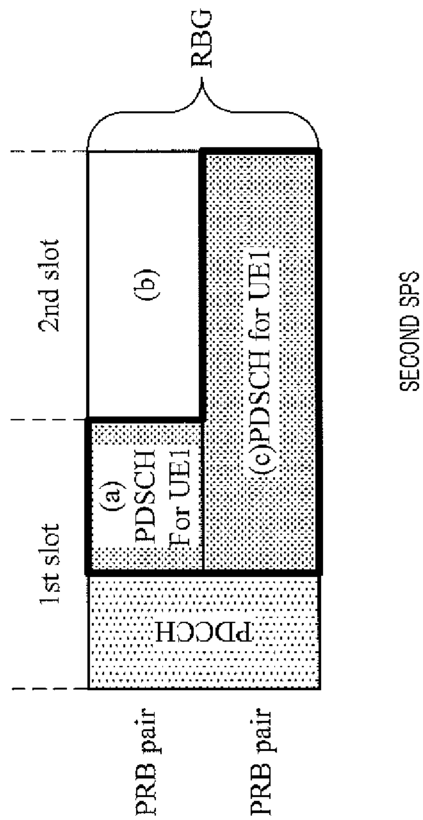


FIG. 12B

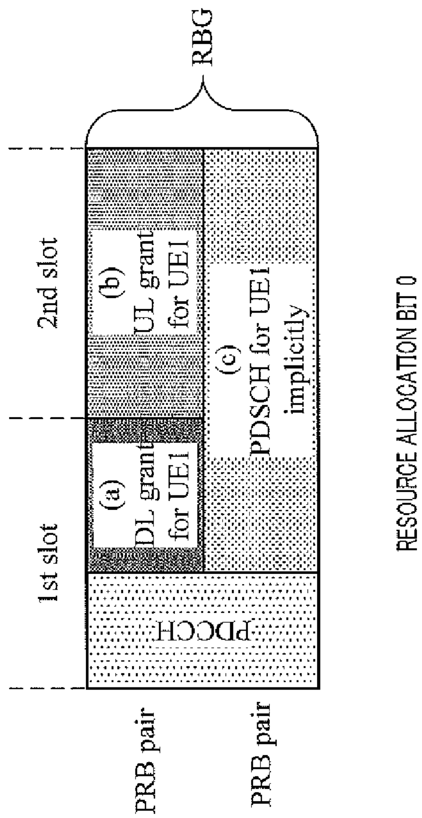


FIG. 13B

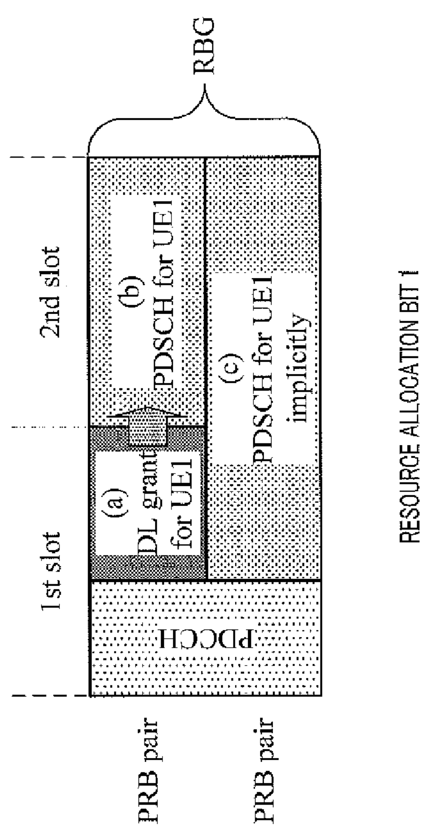
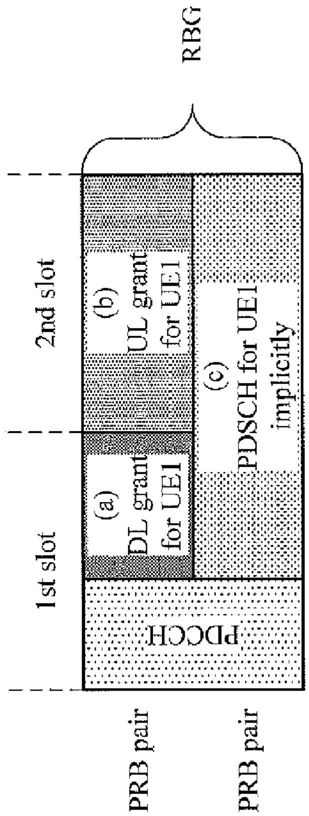
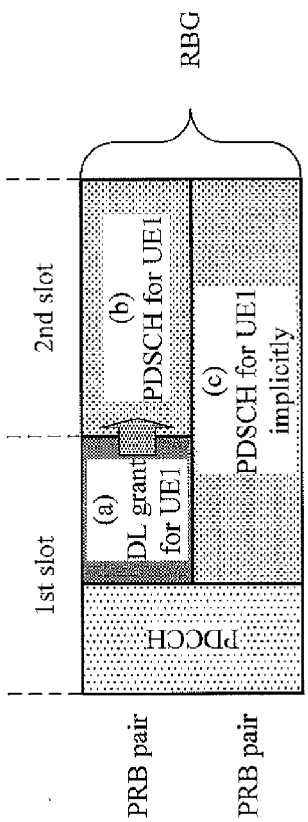


FIG. 13A



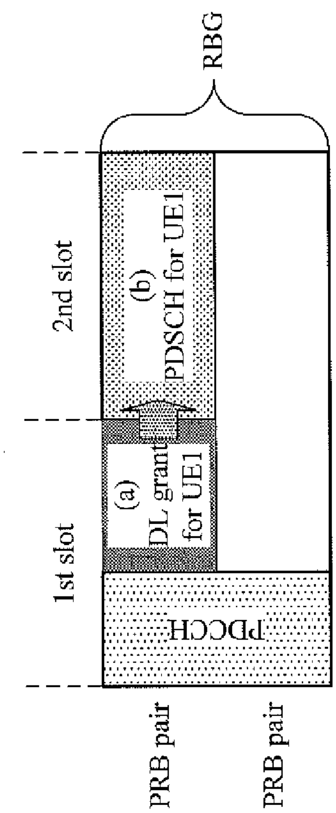
SECOND SPS

FIG. 14B



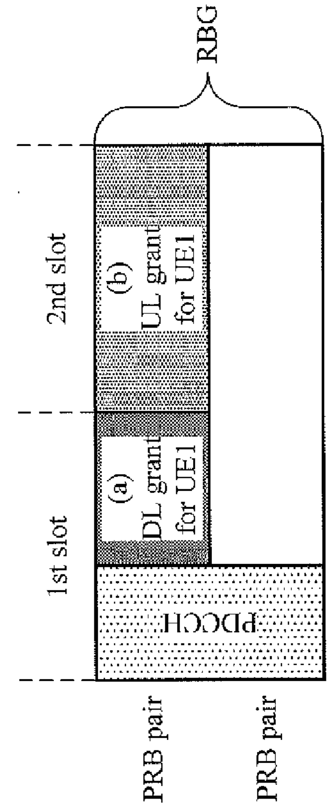
FIRST SPS

FIG. 14A



RESOURCE ALLOCATION BIT 1

FIG. 15A



RESOURCE ALLOCATION BIT 0

FIG. 15B

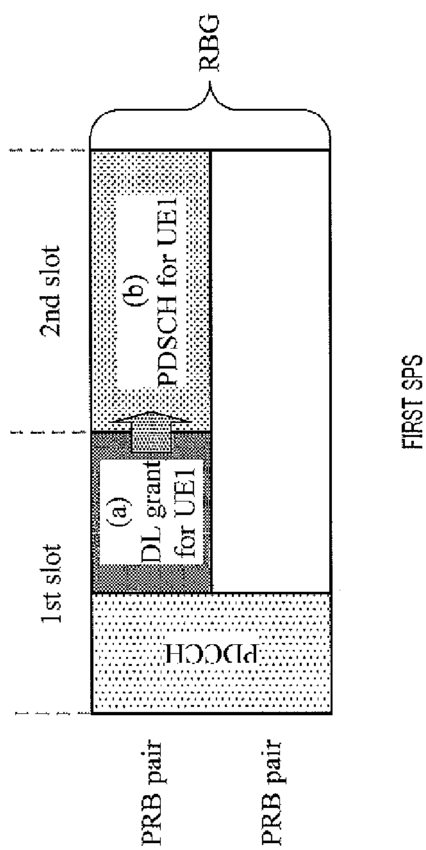


FIG. 16A

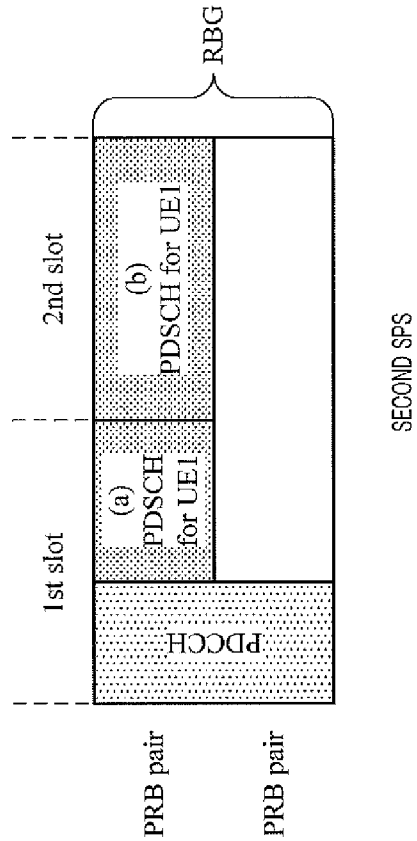


FIG. 16B

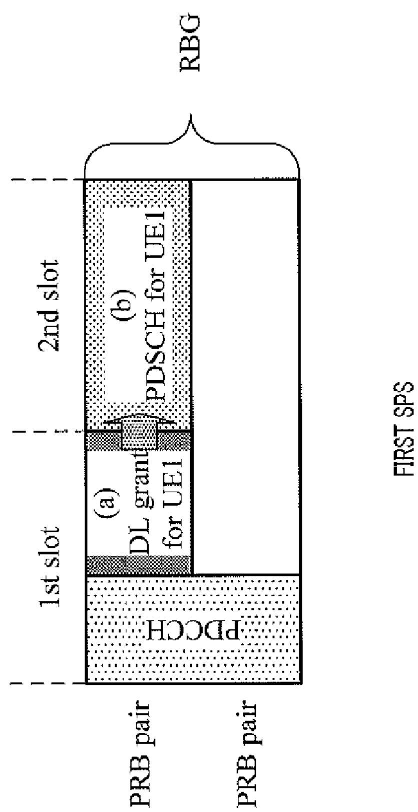


FIG. 17A

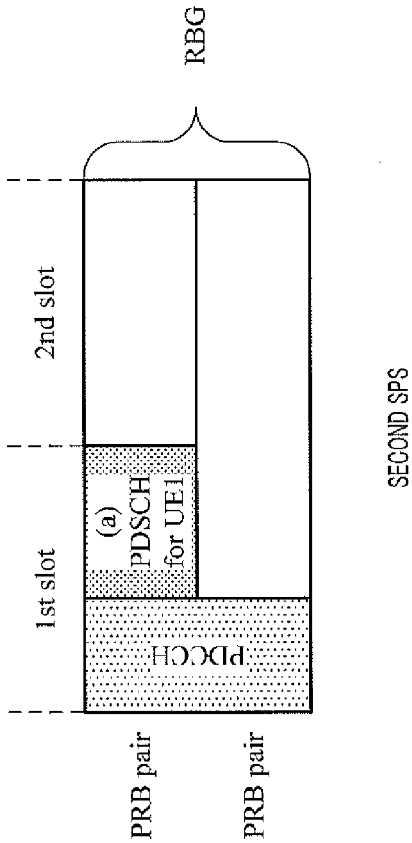
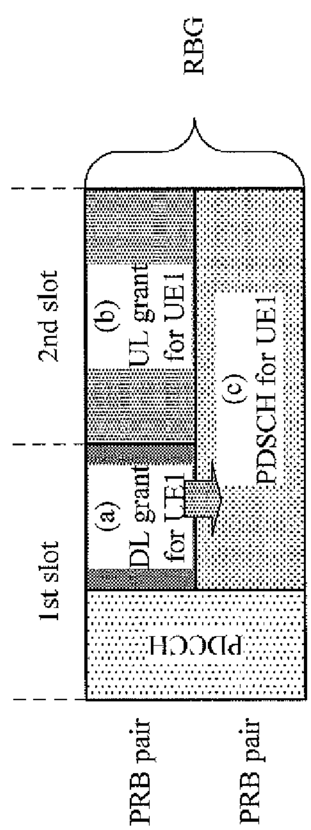
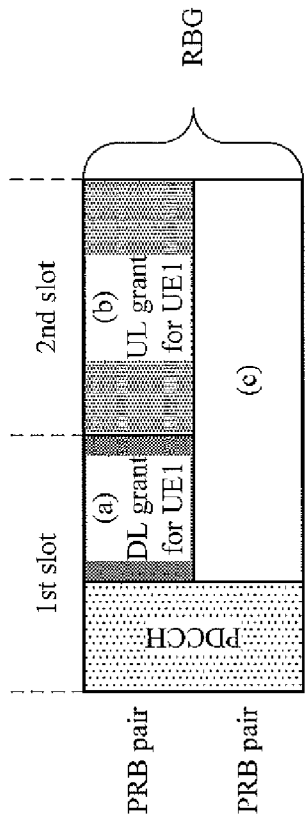


FIG. 17B



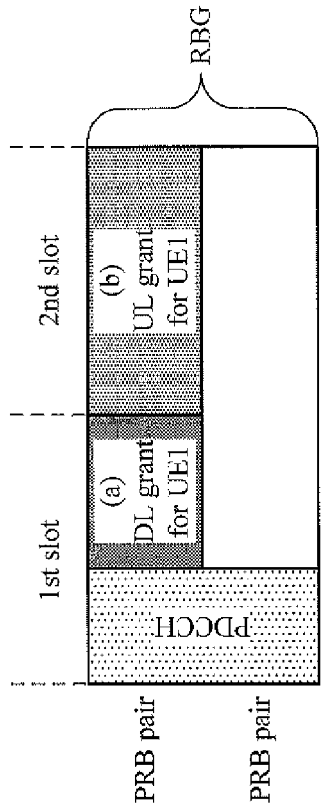
RESOURCE ALLOCATION BIT 1

FIG. 18A



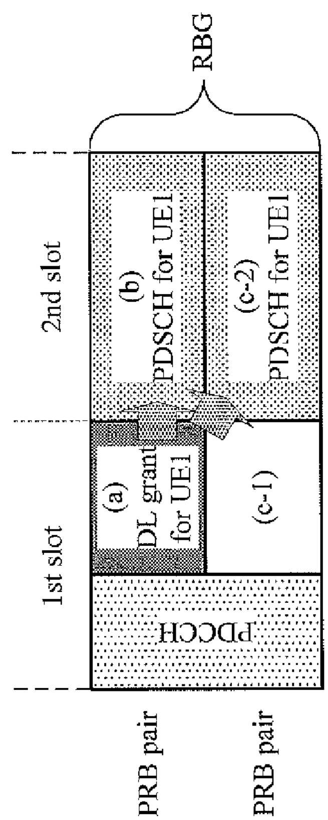
RESOURCE ALLOCATION BIT 0

FIG. 18B



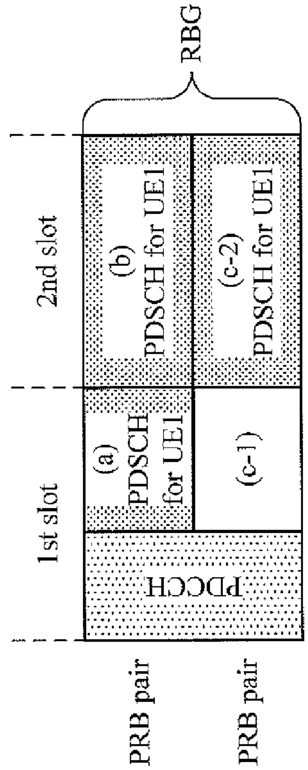
RESOURCE ALLOCATION BIT 0

FIG. 19B



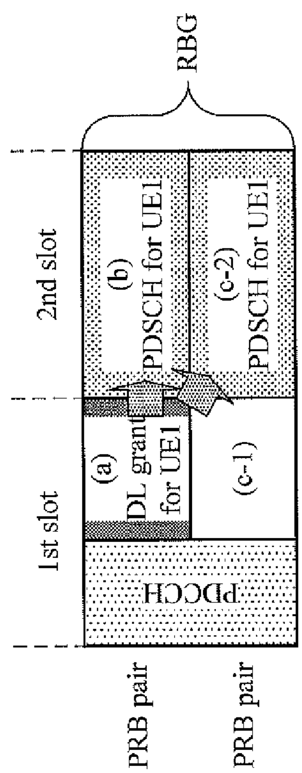
RESOURCE ALLOCATION BIT 1

FIG. 19A



SECOND SPS

FIG. 20B



FIRST SPS

FIG. 20A

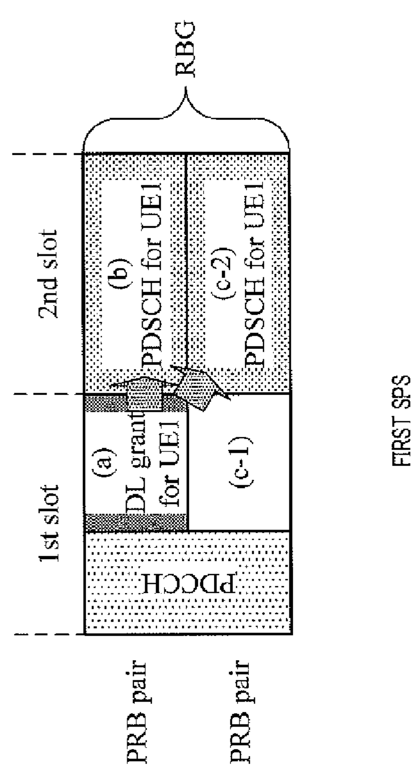


FIG. 21A

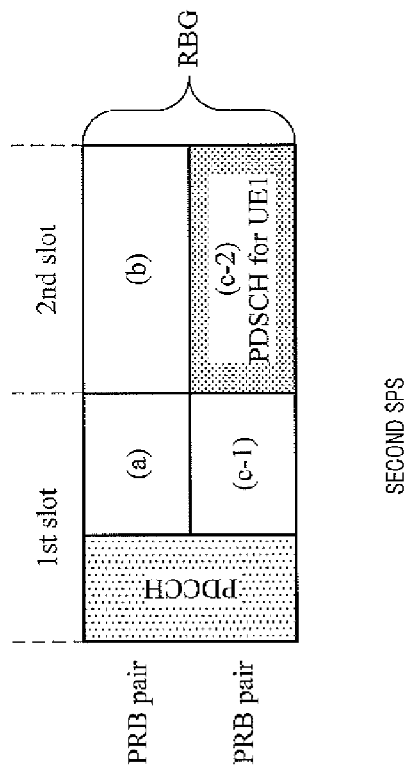
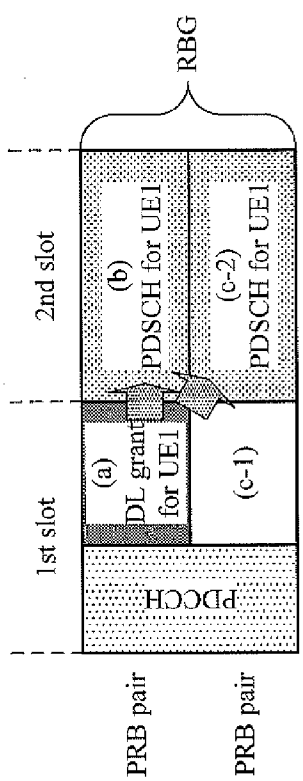
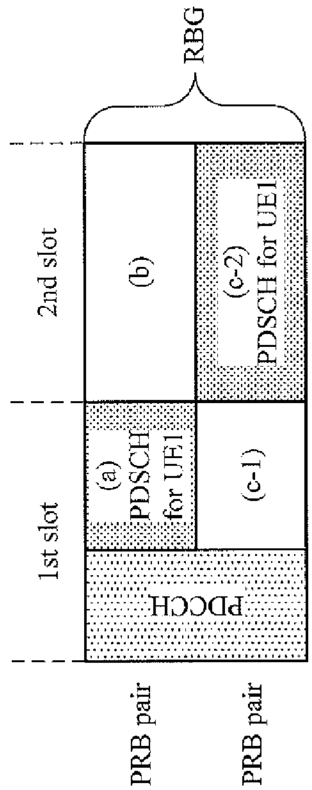


FIG. 21B



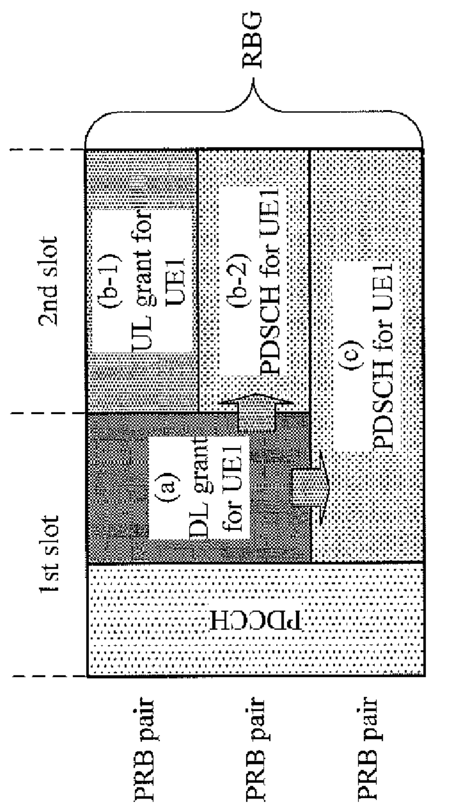
FIRST SPS

FIG. 22A



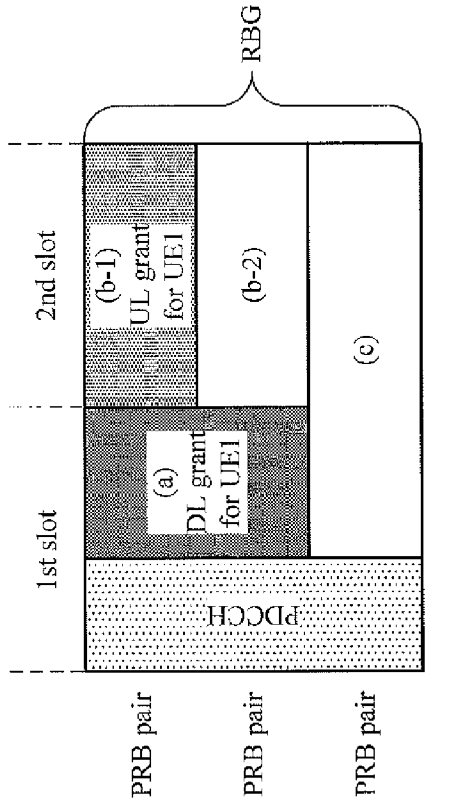
SECOND SPS

FIG. 22B



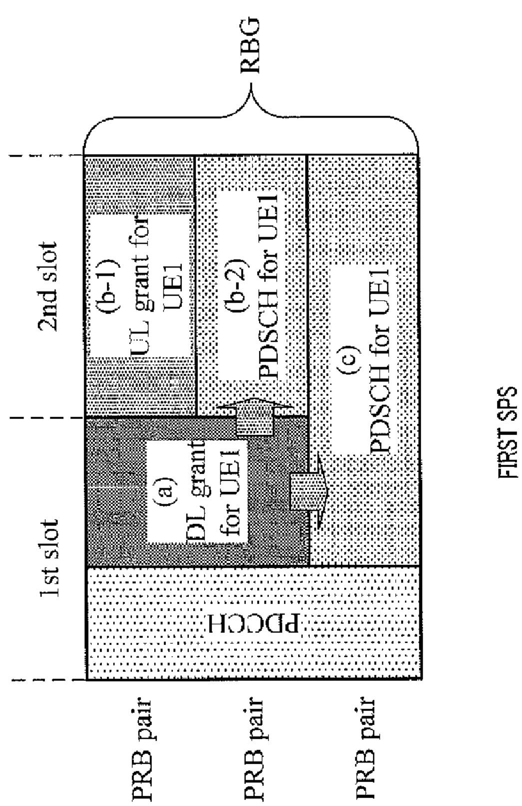
RESOURCE ALLOCATION BIT 1

FIG. 23A



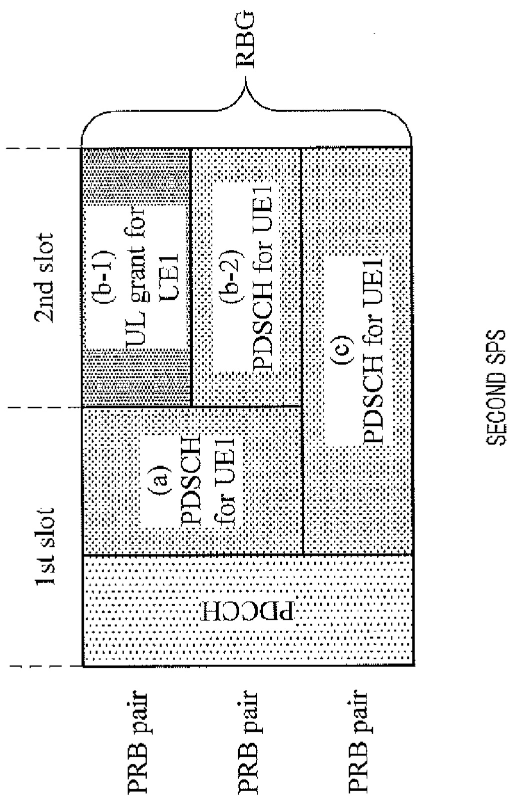
RESOURCE ALLOCATION BIT 0

FIG. 23B



FIRST SPS

FIG. 24A



SECOND SPS

FIG. 24B

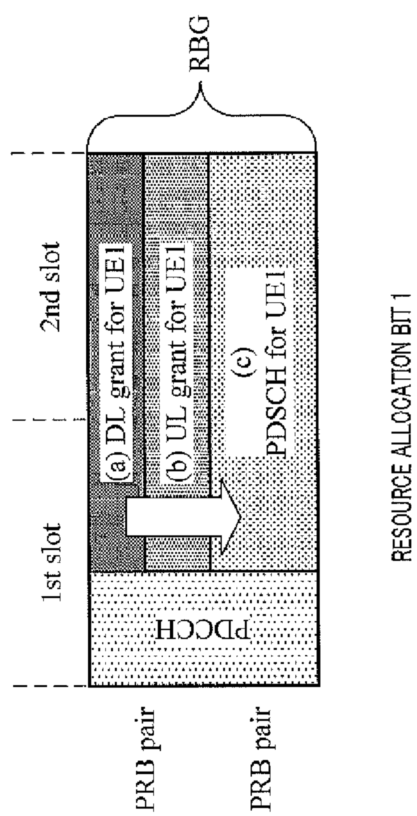


FIG. 25A

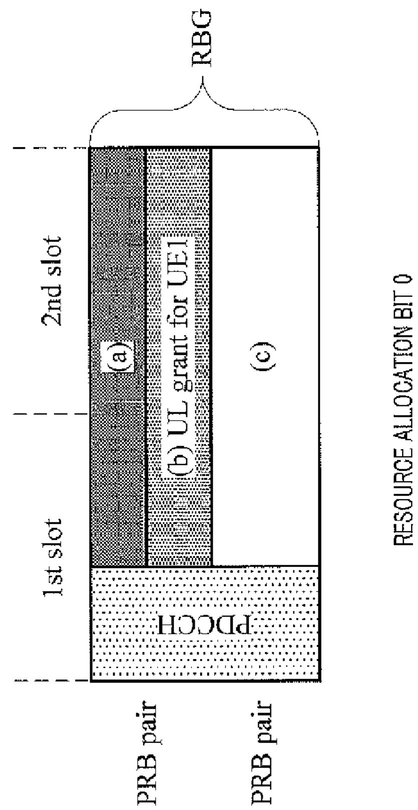
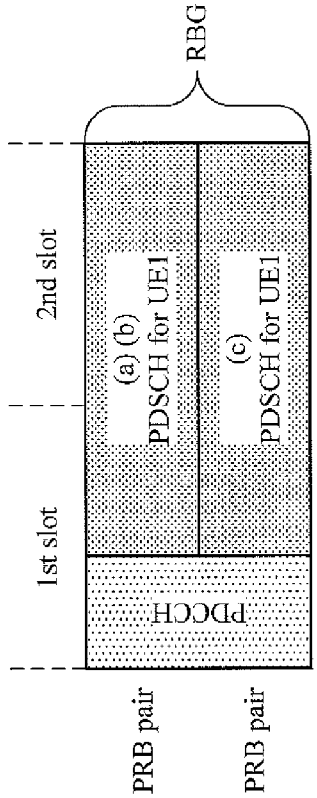
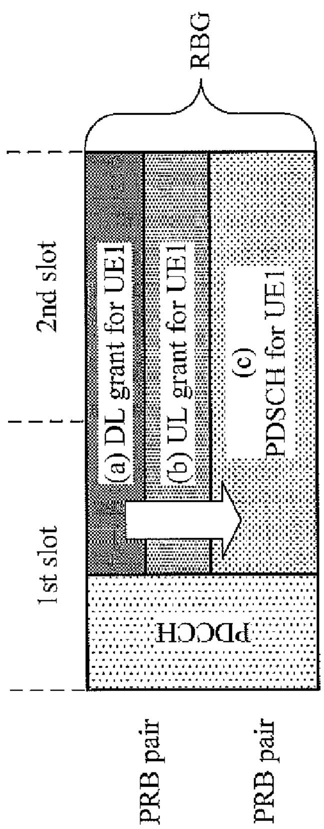


FIG. 25B



SECOND SPS

FIG. 26B



FIRST SPS

FIG. 26A

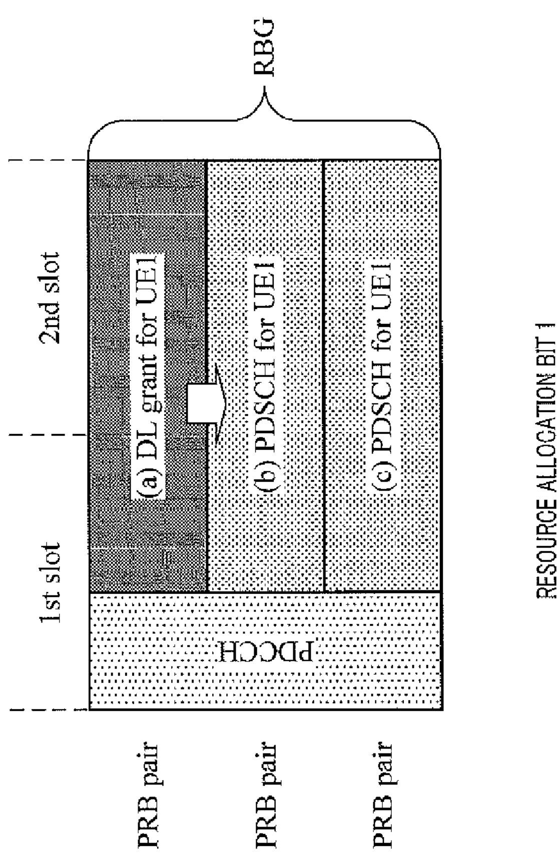


FIG. 27A

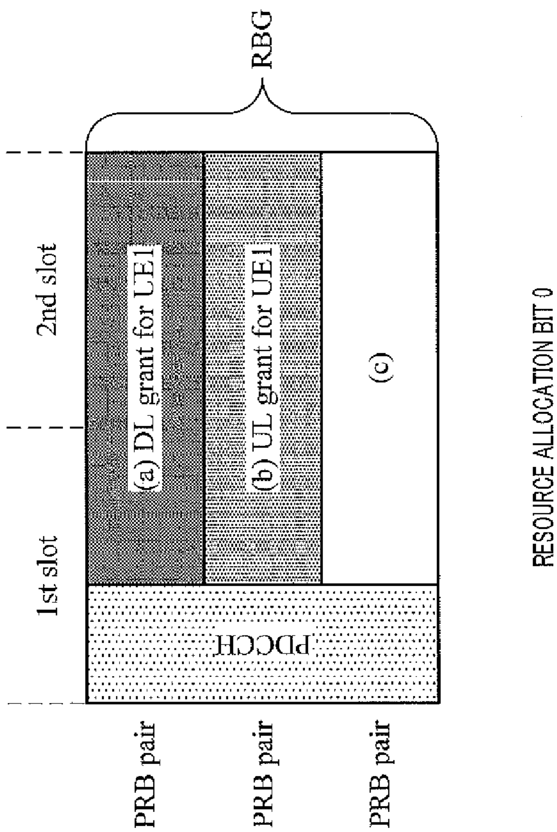
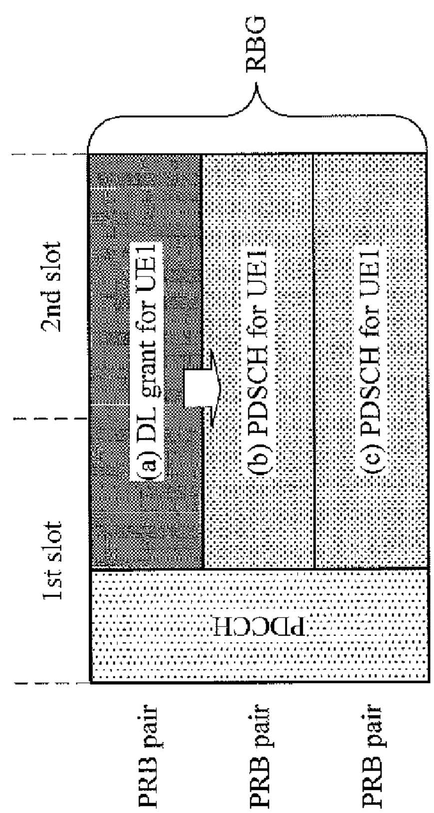
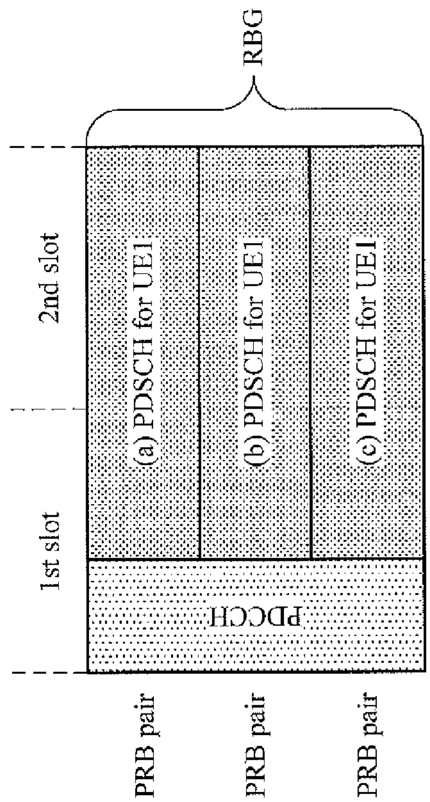


FIG. 27B



FIRST SPS

FIG. 28A



SECOND SPS

FIG. 28B

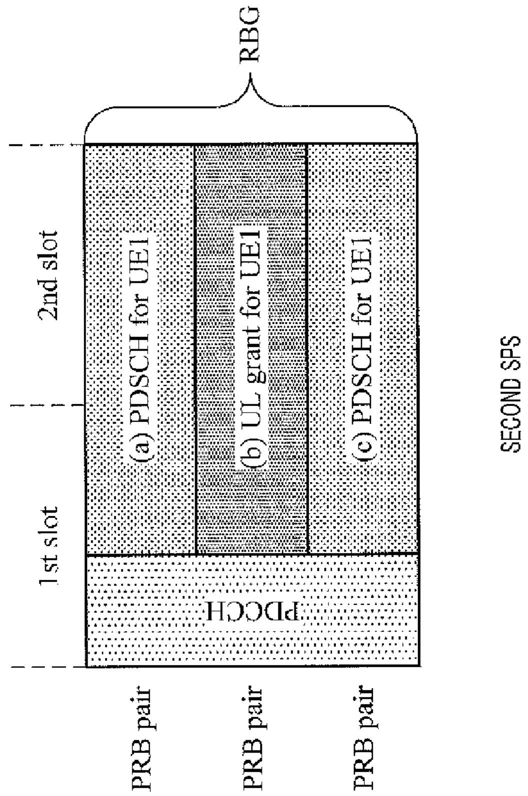


FIG. 29B

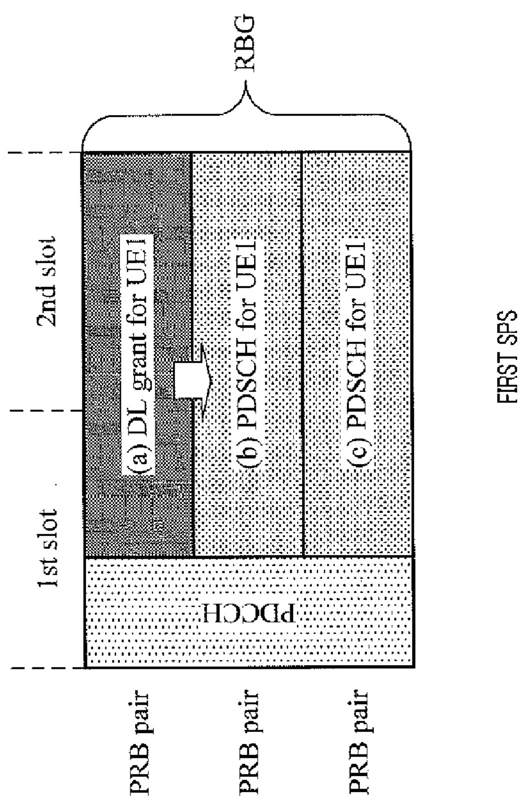


FIG. 29A

TRANSMISSION DEVICE, RECEIVING DEVICE, TRANSMISSION METHOD AND RECEIVING METHOD

TECHNICAL FIELD

The claimed invention relates to a transmission apparatus, a reception apparatus, a transmission method, and a reception method.

BACKGROUND ART

In recent years, it has become common to transmit large-volume data, such as still image data and moving image data in addition to audio data in cellular mobile communication systems, in response to spread of multimedia information. Active studies associated with techniques for achieving a high transmission rate in a high-frequency radio band has been conducted to achieve large-volume data transmission.

When a high frequency radio band is utilized, however, attenuation increases as the transmission distance increases, although a higher transmission rate can be expected within a short range. Accordingly, the coverage area of a radio communication base station apparatus (hereinafter, abbreviated as "base station") decreases when a mobile communication system using a high frequency radio band is actually put into operation. Thus, more base stations need to be installed in this case. The installation of base stations involves reasonable costs, however. For this reason, there has been a high demand for a technique that provides a communication service using a high-frequency radio band, while limiting an increase in the number of base stations.

In order to meet such a demand, studies have been carried out on a relay technique in which a radio communication relay station apparatus (hereinafter, abbreviated as "relay station") is installed between a base station and a radio communication mobile station apparatus (hereinafter, abbreviated as "mobile station") to perform communication between the base station and mobile station via the relay station for the purpose of increasing the coverage area of each base station. The use of relay technique allows a mobile station not capable of directly communicating with a base station to communicate with the base station via a relay station.

An LTE-A (long-term evolution advanced) system for which the introduction of the relay technique described above has been studied is required to maintain compatibility with LTE (long term evolution) in terms of a smooth transition from and coexistence with LTE. For this reason, mutual compatibility with LTE is required for the relay technique as well.

FIG. **1** illustrates example frames in which control signals and data are assigned in the LTE system and the LTE-A system.

In the LTE system, DL (downlink) control signals from a base station to a mobile station are transmitted through a DL control channel, such as PDCCH (physical downlink control channel). In LTE, DL grant indicating DL data assignment and UL (uplink) grant indicating UL data assignment are transmitted through PDCCH. DL grant reports that a resource in the subframe in which the DL grant is transmitted has been allocated to the mobile station. Meanwhile, in an FDD system, UL grant reports that a resource in the fourth subframe after the subframe in which the UL grant is transmitted has been allocated to the mobile station. In a TDD system, UL grant reports that the resource in a subframe transmitted after four or more subframes from the subframe in which the UL grant is transmitted has been allocated to the mobile station. In the TDD system, the subframe to be assigned to the mobile station, or the number of subframes before the assigned subframe in which the UL grant is transmitted is determined in accordance with the time-division pattern of the UL and DL (hereinafter referred to as "UL/DL configuration pattern"). Regardless of the UL/DL configuration pattern, the UL subframe is a subframe after at least four subframes from the subframe in which the UL grant is transmitted.

In the LTE-A system, relay stations, in addition to base stations, also transmit control signals to mobile stations in PDCCH regions in the top parts of subframes. With reference to a relay station, DL control signals have to be transmitted to a mobile station. Thus, the relay station switches the processing to reception processing after transmitting the control signals to the mobile station to prepare for receiving signals transmitted from the base station. The base station, however, transmits DL control signals to the relay station at the time the relay station transmits the DL control signals to the mobile station. The relay station therefore cannot receive the DL control signals transmitted from the base station. In order to avoid such inconvenience in the LTE-A, studies have been carried out on providing a region in which downlink control signals for relay stations are located (i.e., relay PDCCH (R-PDCCH) region) in a data region as illustrated in FIG. **2** in LTE-A. Similar to the PDCCH, locating DL grant and UL grant on the R-PDCCH is studied. In the R-PDCCH, as illustrated in FIG. **1**, locating the DL grant in the first slot and the UL grant in the second slot is studied (refer to Non-patent Literature 1). Locating the DL grant in the first slot reduces a delay in decoding the DL grant, and allows relay stations to prepare for ACK/NACK transmission for DL data (transmitted in the fourth subframes following reception of DL grant in FDD).

Each relay station finds the downlink control signals intended for the relay station by performing blind-decoding on downlink control signals transmitted using an R-PDCCH region from a base station within a resource region indicated using higher layer signaling from the base station (i.e., search space).

As described above, the base station notifies the relay station of the search space corresponding to the R-PDCCH by higher layer signaling. Notification of the search space corresponding to the R-PDCCH may be performed in two different ways: (1) notification using a PRB (physical resource block) pair as a single unit; or (2) notification using an RBG (resource block group) as a single unit. The term, "PRB (physical resource block) pair" refers to a set of PRBs in the first and second slots, whereas the term, "PRB" refers to an individual PRB in either the first or second slot. Hereinafter, a PRB pair may simply be referred to as "PRB." A resource block group (RBG) is a unit used when a plurality of PRBs are scheduled as a group. The size of an RBG is determined on the basis of the bandwidth of the communication system.

R-PDCCH has four aggregation levels, i.e., levels 1, 2, 4, and 8 (for example, refer to Non-patent Literature (hereinafter, abbreviated as "NFL") 1). Levels 1, 2, 4, and 8 respectively have six, six, two, and two mapping candidate positions. The term "mapping candidate position" refers to a candidate region to which control signals are to be mapped. When a single terminal is set with one aggregation level, control signals are actually mapped to one of the multiple mapping candidate positions of the aggregation level. FIG. **2** illustrates example search spaces corresponding to R-PDCCH. The ovals represent search spaces at various aggregation levels. The multiple mapping candidate positions in the search spaces at the different aggregation levels are continuous on VRBs (virtual resource blocks). The mapping candidate positions in the VRBs are mapped to PRBs (physical resource blocks) through higher layer signaling.

In the LTE system, data resources used for transmission of DL or UL data are scheduled by dynamic scheduling or SPS (semi-persistent scheduling). In dynamic scheduling, a base station notifies a terminal of a data resource in each subframe with DL or UL grant. In SPS, upon notification of a data resource from a base station to a terminal with first control signals (DL or UL grant), a series of data is transmitted using predetermined resources in a group of transmission-scheduled subframes until the end of SPS is notified by second control signals. In SPS, two consecutive frames in the group of transmission-scheduled subframes have a predetermined frame interval. The predetermined resources are common between the transmission-scheduled subframes. In SPS, if dynamic scheduling of the data resources is indicated in any subframe in the group of transmission-scheduled subframes, a priority is given to the dynamic scheduling of the subframe, while data transmission of the data resource scheduled by SPS is skipped. SPS is suitable for communication involving small consecutive packets. An example communication involving small consecutive packets is speech communication. SPS applied to audio communication can eliminate the need for indication of the data resources used for mapping small packets using control signals every time, and thus can prevent an increase in the overhead of the control signals relative to the number of packets.

CITATION LIST

Non Patent Literature

NPL 1
3GPP TSG-RAN WG1 Meeting, R1-106478, "Capturing of further agreements on relaying" November 2010

SUMMARY OF INVENTION

Technical Problem

Given the introduction of various apparatuses as radio communication terminals in the future M2M (machine to machine) communication, for example, there is a concern for a shortage of resources in the mapping region for PDCCH (i.e., "PDCCH region") due to an increase in the number of terminals. If PDCCH cannot be mapped due to such a resource shortage, the DL data cannot be scheduled for the terminals. Thus, the resource region for mapping DL data (i.e., "PDCCH (physical downlink shared channel) region") cannot be used even if there is an available region, possibly causing a decrease in the system throughput. Studies have been carried out to solve such resource shortage through locating control signals for terminals served by a base station in a data region to which R-PDCCH is mapped (i.e., "R-PDCCH region for terminals"). Locating the control signals in a data region in such a manner enables transmission power control for control signals transmitted to terminals near a cell edge or interference control for interference to another cell by control signals to be transmitted or interference to the cell from another cell.

The search space corresponding to R-PDCCH for terminals is a resource region to which the control signals transmitted from the base station to the terminals may be mapped. The search space corresponding to R-PDCCH is set for each terminal.

The SPS between base stations and terminals supported in the LTE system is also applied to the SPS between base stations and terminals in the LTE-A system. Thus, the SPS for the mapping of the control signals transmitted from base stations to terminals to R-PDCCH regions for the terminals need to be specified. The SPS for this case, however, has not yet been studied. It has already been determined that LTE-A does not support SPS between base stations and relay stations.

An object of the claimed invention is to provide a transmission apparatus, a reception apparatus, a transmission method, and a reception method that enable transmission of a series of data while the data is distributed to data resources in N transmission subframes (where N is a natural number greater than or equal to two) when control signals are transmitted in a resource region usable for a control channel or data channel.

Solution to Problem

A transmission apparatus according to an aspect of the claimed invention maps control signals for a reception apparatus to a first resource region usable for a control channel or a data channel or to a second resource region usable for a control channel, transmits the mapped signals, and transmits a series of data to the reception apparatus while distributing the series of data to data resources in N transmission subframes (where N is a natural number greater than or equal to two), the transmission apparatus including: a generating section that generates scheduling control signals for the data resources; a setting section that sets the data resources, and a control resource region to which the scheduling control signals are mapped in the first resource region in a resource block group (RBG) being formed of M resource blocks (RBs) (where M is a natural number greater than or equal to two) and being common between the transmission subframes; and a mapping section that maps the series of data to the set data resources and maps the scheduling control signals to the control resource region, in which the setting section sets the resource region set as the control resource region in the first transmission subframe of the N transmission subframes to be the data resource in the transmission subframes except for the first transmission subframe.

A reception apparatus according to an aspect of the claimed invention receives reception signals including control signals transmitted from a transmission apparatus through a first resource region usable for a control channel or a data channel or a second resource region usable for a control channel and receives a series of data being transmitted from the transmission apparatus while being distributed to data resources in N transmission subframes (where N is a natural number greater than or equal to two), the reception apparatus including: a detecting section that detects scheduling control signals for the data resources included in the reception signals; and an extracting section that extracts, from the reception signals, a signal component in a data-component extraction target region corresponding to the data resource in a resource block group (RBG) formed of M resource blocks (RBs) (where M is a natural number greater than or equal to two) including an RB in which the scheduling control signals are detected, the resource block group (RBG) being common between the transmission subframes, in which the extracting section treats a resource region in which the scheduling control signals are detected in the first transmission subframe of the N transmission subframes as the data-component extraction target region in the transmission subframes except for the first transmission subframe.

A transmission method according to an aspect of the claimed invention is a method of mapping control signals for a reception apparatus in a first resource region usable for a control channel or a data channel or in a second resource region usable for a control channel, transmitting the mapped signals, and transmitting a series of data to the reception apparatus while distributing the series of data to data resources in N transmission subframes (where N is a natural number greater than or equal to two), the method including: generating scheduling control signals for the data resources; setting the data resources, and a control resource region to which the scheduling control signals are mapped in the first resource region in a resource block group (RBG) being formed of M resource blocks (RBs) (where M is a natural number greater than or equal to two) and being common between the transmission subframes; and mapping the series of data to the set data resources and mapping the scheduling control signals to the control resource region, wherein a resource region set as the control resource region in the first transmission subframe of the N transmission subframes is set as the data resources in the transmission subframes except for the first transmission subframe.

A reception method according to an aspect of the claimed invention is a method of receiving reception signals including control signals transmitted from a transmission apparatus through a first resource region usable for a control channel or a data channel or a second resource region usable for a control channel and receiving a series of data being transmitted from transmission apparatus while being distributed to data resources in N transmission subframes (where N is a natural number greater than or equal to two), the method including: detecting scheduling control signals for the data resources included in the reception signals; and extracting, from the reception signals, a signal component in a data-component extraction target region corresponding to the data resources in a resource block group (RBG) formed of M resource blocks (RBs) (where M is a natural number greater than or equal to two) including a RB in which the scheduling control signals are detected, the resource block group (RBG) being common between the transmission subframes, wherein a resource region in which the scheduling control signals are detected in the first transmission subframe of the N transmission subframes is to be the data-component extraction target region in the transmission subframes except for the first transmission subframe.

Advantageous Effects of Invention

The claimed invention can provide a transmission apparatus, a reception apparatus, a transmission method, and a reception method that enable transmission of a series of data while the data is distributed to data resources in N transmission subframes (where N is a natural number greater than or equal to two) when control signals are transmitted in a resource region usable for a control channel or data channel.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** illustrates example frames containing control signals and data assigned thereto, in the LTE system and the LTE-A system;

FIG. **2** illustrates example search spaces corresponding to R-PDCCH;

FIGS. **3**A and **3**B are diagrams provided for data resource scheduling for a relay station;

FIGS. **4**A and **4**B are diagrams illustrating an example data transmission method;

FIG. **5** is a main configuration diagram of a base station according to Embodiment 1 of the claimed invention;

FIG. **6** is a main configuration diagram of a terminal according to Embodiment 1 of the claimed invention;

FIG. **7** is a block diagram illustrating a configuration of the base station according to Embodiment 1 of the claimed invention;

FIG. **8** is a diagram provided for describing a mapping resource pattern according to Embodiment 1 of the claimed invention;

FIG. **9** is a block diagram illustrating a configuration of the terminal according to Embodiment 1 of the claimed invention;

FIGS. **10**A and **10**B are diagrams provided for describing a mapping resource pattern according to Embodiment 3 of the claimed invention;

FIGS. **11**A and **11**B are diagrams provided for describing a mapping resource pattern according to Embodiment 4 of the claimed invention;

FIGS. **12**A and **12**B are diagrams provided for describing a mapping resource pattern according to Embodiment 5 of the claimed invention;

FIGS. **13**A and **13**B are diagrams provided for describing PDSCH scheduling method **1** by DL grant;

FIGS. **14**A and **14**B are diagrams provided for describing a mapping resource pattern according to PDSCH scheduling method **1**;

FIGS. **15**A and **15**B are diagrams provided for describing PDSCH scheduling method **2** by DL grant;

FIGS. **16**A and **16**B are diagrams provided for describing a mapping resource pattern according to PDSCH scheduling method **2**;

FIGS. **17**A and **17**B are diagrams provided for describing another mapping resource pattern according to PDSCH scheduling method **2**;

FIGS. **18**A and **18**B are diagrams provided for describing PDSCH scheduling method **3** by DL grant;

FIGS. **19**A and **19**B are diagrams provided for describing PDSCH scheduling method **4** by DL grant;

FIGS. **20**A and **20**B are diagrams provided for describing a mapping resource pattern according to PDSCH scheduling method **4**;

FIGS. **21**A and **21**B are diagrams provided for describing another mapping resource pattern according to PDSCH scheduling method **4**;

FIGS. **22**A and **22**B are diagrams provided for describing another mapping resource pattern according to PDSCH scheduling method **4**;

FIGS. **23**A and **23**B are diagrams provided for describing PDSCH scheduling method **5** by DL grant;

FIGS. **24**A and **24**B are diagrams provided for describing a mapping resource pattern according to PDSCH scheduling method **5**;

FIGS. **25**A and **25**B are diagrams provided for describing PDSCH scheduling method **6** by DL grant;

FIGS. **26**A and **26**B are diagrams provided for describing a mapping resource pattern according to PDSCH scheduling method **6**;

FIGS. **27**A and **27**B are diagrams provided for describing PDSCH scheduling method **7** by DL grant;

FIGS. **28**A and **28**B are diagrams provided for describing a mapping resource pattern according to PDSCH scheduling method **7**; and

FIGS. **29**A and **29**B are diagrams provided for describing another mapping resource pattern according to PDSCH scheduling method **7**.

DESCRIPTION OF EMBODIMENTS

In case of transmission of DL grant in an R-PDCCH region for a relay station from a base station so as to assign PDSCH in units of RBGs to the relay station, the DL grant and PDSCH may be located on the same RBG in a given subframe. That is, as illustrated in FIG. **3**A, if DL grant is mapped to given RBG region (a) in a given subframe, regions (b) and (c) in the subframe are allocated to the PDSCH by the DL grant. The RBG is formed of M PRB pairs (where M is a natural number greater than or equal to two). Region (a) resides in a first PRB pair allocated to the DL grant (i.e., "allocated PRB" pair), in a first slot other than the PDCCH region. Region (b) belongs to a second slot in the allocated PRB pair and is provided as a search space for an UL grant. Region (c) resides among the M PRB pairs, which form the RBG including the allocated FRB pair, in a region other than the allocated PRB pair and the PDCCH region. As illustrated in FIG. **3**A, if the RBG is allocated to the PDSCH, the value of the resource allocation bit of the RBG in the DL grant is set to "1".

In a case where DL and UL grants are mapped to the same RBG in a given subframe, the DL grant is mapped to region (a), and the UL grant is mapped to region (b), as illustrated in FIG. **3**B. Regions (b) and (c) are not allocated to PDSCH. In such a case, zero is assigned to the value of the resource allocation bit for the RBG in the DL grant. Thus, a terminal that receives DL control signals can determine whether the resource scheduling is that illustrated in FIG. **3**A or **3**B depending on the value, i.e., zero or one, of the resource allocation bit in the DL grant intended for the terminal for each RBG.

Thus, similar to the R-PDCCH region for a relay station, in a case of transmission of a DL grant in an R-PDCCH region for a terminal from a base station so as to assign PDSCH in units of RBGs to the terminal, the DL grant and the PDSCH may be located on the same RBG in a given subframe. In a case where the DL grant and PDSCH are placed on the same RBG, region (a) is excluded as a resource for the PDSCH, while regions (b) and (c) are allocated to the PDSCH as resources. Thus, the number of resources for the PDSCH differs between a case where DL grant and PDSCH are located on the same RBG in a given subframe and a case where the DL grant in a given RBG in a given subframe is not mapped and regions (a), (b), and (c) are all allocated to the PDSCH as resources.

Resources of high channel quality are desirably allocated to the DL grant and DL data. In SPS, an assumption is made that the resources are mainly allocated to small data sets, such as VoIP. In a case of small data transmission, the data resource is located in the same RBG as the DL grant to desirably reduce the number of RBGs to be used. Thus, in SPS, DL grant according to SPS and the data resource allocated by the DL grant tend to located in the same RBG.

Accordingly, the inventors of this application have found the following problems occur in SPS in case of transmission of DL grant from a base station to assign PDSCH in units of RBGs to a terminal. In order for the PDSCH scheduling method illustrated in FIGS. **3**A and **3**B to be applied to SPS, data transmission method using data resources (i.e., regions (b) and (c)) scheduled for a first transmission-scheduled subframe (which is also referred to as "transmission subframe") in SPS, also in the second and subsequent transmission-scheduled subframes (see FIGS. **4**A and B) may be possible. Such a data transmission method, however, creates wasted resources in the second and subsequent transmission-scheduled subframes in SPS because region (a) is not used as a data resource.

A first object of the claimed invention is to reduce the number of such wastefully unused resources. This object is achieved mainly through Embodiments 1, 2, and 5. For example, in Embodiment 1, region (a) is used as a data resource in the second and subsequent transmission-scheduled subframes in SPS. Such a data transmission method is particularly effective at a high aggregation level of R-PDCCH. This is because a high aggregation level leads to a larger number of allocated PRBs. For example, at R-PDCCH aggregation level 4, regions (a) in the four PRBs to which the DL grants are mapped in the first transmission-scheduled subframe can be used as PDSCH regions in the second and subsequent transmission-scheduled subframes.

The inventors of this application have also found that UL grant transmission is required even for DL data transmission target PRBs in transmission-scheduled subframes with SPS. Consequently, a second object of the claimed invention is to achieve DL data transmission with SPS that enables UL grant transmission even for DL data transmission target PRBs in transmission-scheduled subframes with SPS. This object is achieved mainly through Embodiments 3, 4, and 5.

Embodiments of the claimed invention will be described in detail with reference to the drawings. In the embodiments, the same elements will be assigned the same reference numerals, and any duplicate description of the elements is omitted.

Embodiment 1

Overview of Communication System

A communication system according to Embodiment 1 of the claimed invention includes a transmission apparatus and a reception apparatus. Specifically, in this embodiment of the claimed invention, a description will be provided while the transmission apparatus is referred to as base station **100**, and the reception apparatus is referred to as terminal **200**. The communication system is an LTE-A system, for example. Base station **100** is an LTE-A base station, and terminal **200** is an LTE-A terminal, for example.

FIG. **5** illustrates a main configuration of base station **100** according to Embodiment 1 of the claimed invention. Base station **100** transmits control signals for terminal **200** after mapping the control signals to a first resource region usable for a control channel or a data channel (R-PDCCH for a terminal, in this case) or in a second resource region usable for a control channel (a PDCCH, in this case). Base station **100** distributes a series of data to data resources in N transmission-scheduled subframes (where N is a natural number greater than or equal to two) and transmits the distributed data to terminal **200**, Control signal generating section **103** generates scheduling control signals (DL grant, in this case) for allocating the data resource. Then, transmission controlling section **102** sets a control resource region for mapping the data resource and the scheduling control signals to a first resource region on a resource block group (RBG) formed of M resource blocks (PRB pair, in this case) (where M is a natural number greater than or equal to two) and being common between the transmission-scheduled subframes. Signal scheduling section **106** maps the series of data to the set data resources and scheduling control signals in the control resource region.

The resource region set as a control resource region in the first transmission-scheduled subframe of the N transmission-scheduled subframes is set as data resources in the transmission-scheduled subframes except for the first transmission-scheduled subframe.

FIG. **6** illustrates a main configuration of terminal **200** according to Embodiment 1 of the claimed invention. Terminal **200** receives control signals from a transmission apparatus in a first resource region usable for a control channel or a data channel or in a second resource region usable for a control channel. Terminal **200** receives the series of data distributed to the data resources in the N transmission-scheduled subframes (where N is a natural number greater than or equal to two) and transmitted from base station **100**. Then, control-signal receiving section **205** detects scheduling control signals for the data resource contained in the received signals. Signal demultiplexing section **202** extracts, from the received signals, a signal component corresponding to a data-component extraction target region in the resource block group (RBG) formed of M RBs (where M is a natural number greater than or equal to two) including resource blocks (which are a PRB pair, in this case) in which scheduling control signals are detected by control-signal receiving section **205** and being common between the transmission-scheduled subframes.

The resource region in which scheduling control signals are detected in the first transmission-scheduled subframe of the N transmission-scheduled subframes is set as the data-component extraction target region in the second and subsequent transmission-scheduled subframes.

(Configuration of Base Station **100**)

FIG. **7** is a block diagram illustrating a configuration of base station **100** according to Embodiment 1 of the claimed invention. In FIG. **7**, base station **100** includes scheduling method determining section **101**, transmission controlling section **102**, control-signal generating section **103**, error-correction coding section **104**, modulation section **105**, signal scheduling section **106**, radio transmitting section **107**, radio receiving section **108**, demodulation section **109**, and error-correction decoding section **110**.

Scheduling method determining section **101** receives "transmission signal information" and "report information" transmitted from terminal **200**. The "transmission signal information" represents the characteristics of the transmission data signals and contains, for example, the type of communication, such as speech communication or data communication, the data size of the transmission data signals, and/or the QoS (quality of service). The "report information" contains information such as a scheduling request and/or a buffering state report transmitted from terminal **200**.

Scheduling determining section **101** selects "dynamic scheduling" or "SPS" as the resource scheduling method to be applied to the transmission of resource allocation target data signals on the basis of the transmission signal information and the report information. The identification information for the selected resource scheduling method (hereinafter, simply referred to as "scheduling identification information") is transmitted to transmission controlling section **102**.

If there are any data signals to be transmitted, transmission controlling section **102** takes, as input, the scheduling identification information outputted from scheduling method determining section **101**. Transmission controlling section **102** determines the "mapping resource pattern" of the control signals and the data signals based on the scheduling identification information, and outputs the determined information on the mapping resource pattern to signal scheduling section **106**.

The "mapping resource pattern" for the scheduling identification information indicating SPS has the following specific structure:

(1) mapping resource pattern **1** contains N transmission-scheduled subframes (where N is a natural number greater than or equal to two);

(2) in the first transmission-scheduled subframe of mapping resource pattern **1**, region (a), which is described above, is allocated to a mapping resource for the DL grant, while regions (b) and (c) are allocated to data resources; and

(3) in the second and subsequent transmission-scheduled subframes of mapping resource pattern **1**, regions (a), (b), and (c) are all allocated to data resources (see FIG. **8**). FIG. **8** illustrates a specific case of the transmission-scheduled subframes, where M is "2."

Upon reception of the scheduling identification information, transmission controlling section **102** outputs a DL-grant generation instruction together with the scheduling identification information to control-signal generating section **103**. In a case where the received "report information" contains a scheduling request for the UL data signals, transmission controlling section **102** determines the resource for mapping the UL grant and outputs information on the resource to signal scheduling section **106** while outputting an UL-grant generation instruction to control-signal generating section **103**.

Upon reception of SPS-transmission complete information, transmission controlling section **102** outputs the DL-grant generation instruction together with the SPS-transmission complete information to control-signal generating section **103**.

Upon reception of the scheduling identification information and the DL-grant generation instruction, control-signal generating section **103** generates DL grant scrambled with an RNTI (radio network temporary identity) corresponding to the scheduling identification information and outputs the scrambled DL grant to signal scheduling section **106**.

Upon reception of the UL-grant generation instruction, control-signal generating section **103** generates and sends UL grant to signal scheduling section **106**.

Upon reception of the SPS-transmission complete information and the DL-grant generation instruction, control-signal generating section **103** generates DL grant containing the SPS-transmission complete information.

Error-correction coding section **104** receives transmission data signals, performs error-correction coding on the received transmission data signals, and outputs the coded transmission data signals to modulation section **105**.

Modulation section **105** modulates the signals received from error-correction coding section **104** and outputs the modulated transmission data signals to signal scheduling section **106**.

Signal scheduling section **106** maps the DL grant received from control-signal generating section **103** and the modulated transmission data signals received from modulation section **105** to the resource based on the mapping resource pattern from transmission controlling section **102**. Signal scheduling section **106** maps the UL grant received from control-signal generating section **103** to the resource indicated by the information on the mapping resource for the UL grant received from transmission controlling section **102**. Such mapping of the transmission data signals and the control signals to predetermined resources generates transmission signals. The transmission signals are outputted to radio transmitting section **107**.

Radio transmitting section **107** performs radio transmission processing such as up-conversion on input signals and transmits the processed signals via an antenna.

Radio receiving section **108** receives signals transmitted from terminal **200** via the antenna, performs radio processing such as down-conversion on the received signals, and outputs the processed signals to demodulation section **109**.

Demodulation section **109** demodulates the input signals and outputs the demodulated signals to error-correction decoding section **110**.

Error-correction decoding section **110** decodes the input signals to the report information and received data signals from terminal **200**. The obtained report information from terminal **200** is transmitted to scheduling method determining section **101** and transmission controlling section **102**. The received data signals are transmitted to the subsequent functional component.

(Configuration of Terminal **200**)

FIG. **9** is a block diagram illustrating a configuration of terminal **200** according to Embodiment 1 of the claimed invention. Referring to FIG. **9**, terminal **200** includes radio receiving section **201**, signal demultiplexing section **202**, demodulation section **203**, error-correction decoding section **204**, control-signal receiving section **205**, error-correction coding section **206**, modulation section **207**, signal scheduling section **208**, and radio transmitting section **209**.

Radio receiving section **201** receives, via an antenna, signals transmitted from base station **100**, performs radio processing such as down-conversion on the received signals, and outputs the processed signals to signal demultiplexing section **202**.

Signal demultiplexing section **202** outputs the signals received from radio receiving section **201** to control-signal receiving section **205**.

Signal demultiplexing section **202** extracts a signal component corresponding to the data resource indicated by the information on the mapping resource pattern from control-signal receiving section **205** (i.e., signal component corresponding to the DL data signals) from the received signal and outputs the extracted signals to demodulation section **203**.

Demodulation section **203** demodulates the signals from signal demultiplexing section **202** and outputs the demodulated signals to error-correction decoding section **204**.

Error-correction decoding section **204** decodes the demodulated signals outputted from demodulation section **203** and outputs the decoded received data signals.

Control-signal receiving section **205** extracts a signal component corresponding to the R-PDCCH region from the received signals to be received from signal demultiplexing section **202** and performs blind decoding on the extracted signal component to detect control signals (DL or UL grant) intended for the terminal **200**. As described above, since the DL grant is scrambled with an RNTI for SPS or dynamic scheduling, the scheduling identification information can be obtained by descrambling the DL grant with an RNTI for SPS and an RNTI for dynamic scheduling.

In a case where the scheduling identification information in the detected DL grant indicates SPS, control-signal receiving section **205** outputs the information on the mapping resource pattern for SPS to signal demultiplexing section **202**. The mapping resource pattern as described herein is the same as the one used for base station **100**.

Control-signal receiving section **205** outputs the detected UL grant to signal scheduling section **208**.

Error-correction coding section **206** uses the transmission data signals as input, performs error-correction coding on the transmission data signals, and outputs the coded signal to modulation section **207**.

Modulation section **207** modulates the signals outputted from error-correction coding section **206** and outputs the modulated signals to signal scheduling section **208**.

Signal scheduling section **208** maps the signals outputted from modulation section **207**, in accordance with the UL grant to be received from control-signal receiving section **205** and outputs the mapped signals to radio transmitting section **209**.

Radio transmitting section **209** performs radio transmission processing such as up-conversion on the input signals and transmits the processed signals via an antenna.

(Operations of Base Station **100** and Terminal **200**)

The operations of base station **100** and terminal **200** configured in the manner described above will be described. Specifically, the description focuses on transmission of control signals through R-PDCCH for a terminal and SPS selected as the scheduling method.

Transmission controlling section **102** in base station **100** transmits information on mapping resource pattern **1** for SPS to signal scheduling section **106**.

Control signal generating section **103** generates DL grant containing scheduling identification information and outputs the DL grant to signal scheduling section **106**.

Signal scheduling section **106** maps the DL grant from control signal generating section **103** and the modulated transmission data signals from modulation section **105** to the resource based on mapping resource pattern **1** to be received from transmission controlling section **102**. The mapping of such transmission data signals and control signals to a predetermined resource generates transmission signals. The transmission signals are then transmitted to terminal **200**.

Control-signal receiving section **205** in terminal **200** extracts a signal component corresponding to the R-PDCCH region from the received signal to be received from signal demultiplexing section **202** and performs blind decoding on the extracted signal component to detect the control signals (DL or UL grant) intended for terminal **200**.

Control-signal receiving section **205** outputs the information on mapping resource pattern **1** for SPS to signal demultiplexing section **202**.

Signal demultiplexing section **202** extracts a signal component corresponding to the data resource indicated by the information on mapping resource pattern **1** from control-signal receiving section **205** (i.e., signal component corresponding to DL data signals) from the received signals and outputs the extracted signals to demodulation section **203**.

According to the embodiment described above, base station **100** maps control signals for terminal **200** to a first resource region usable for a control channel or a data channel (R-PDCCH for a terminal, in this case) or to a second resource region usable for a control channel (PDCCH, in this case) and transmits the mapped signals. Base station **100** transmits a series of data to terminal **200** while distributing the series of data to the data resources in the N transmission-scheduled subframes (where N is a natural number greater than or equal to two). Transmission controlling section **102** sets the data resource and a control resource region to which scheduling control signals (i.e., DL grant, in this case) are mapped in the first resource region in a resource block group (RBG), which is formed of M resource blocks (each corresponding to a PRB pair, in this case) (where M is a natural number greater than or equal to two) and which is common between the transmission-scheduled subframes.

The resource region set as a control resource region in the first transmission-scheduled subframe of the N transmission-scheduled subframes is set as a data resource in the transmission-scheduled subframes except for the first transmission-scheduled subframe.

In this way, the resource region (region (a), in this case) set as a control resource in the first transmission-scheduled subframe can be prevented from being left unused in the second and subsequent transmission-scheduled subframes.

Specifically, in Embodiment 1, as described above, regions (a), (b), and (c) are all used as data resources in the second and subsequent transmission-scheduled subframes.

According to this embodiment, terminal **200** receives control signals from a transmission apparatus in a first resource region usable for a control channel or a data channel or in a second resource region usable for a control channel. Terminal **200** receives the series of data distributed to the data resources in the N transmission-scheduled subframes (where N is a natural number greater than or equal to two) and transmitted from base station **100**. Signal demultiplexing section **202** extracts, from the received signals, a signal component corresponding to a data-component extraction target region in the resource block group (RBG) formed of M RBs (where M is a natural number greater than or equal to two) containing resource blocks (which are a PRB pair, in this case) in which scheduling control signals are detected by control-signal receiving section **205** and being common between the transmission-scheduled subframes.

The resource region from which scheduling control signals are detected in the first transmission-scheduled subframe of the N transmission-scheduled subframes is to be the data-component extraction target region in the second and subsequent transmission-scheduled subframes.

In this way, the resource region (region (a), in this case) set as a control resource in the first transmission-scheduled subframe can be prevented from being left unused in the second and subsequent transmission-scheduled subframes.

In particular, in Embodiment 1, as described above, regions (a), (b), and (c) are all data-component extraction target regions in the second and subsequent transmission-scheduled subframes.

Embodiment 2

Embodiment 2 relates to a variation of the mapping resource pattern corresponding to SPS.

Specifically, mapping resource pattern **2** according to Embodiment 2 has the following configuration:

(1) mapping resource pattern **2** includes N transmission-scheduled subframes (where N is a natural number greater than or equal to two);

(2) in the first transmission-scheduled subframe of mapping resource pattern **2**, region (a), which is described above, is to be a mapping resource for DL grant, but regions (b) and (c) are not to be data resource; and

(3) all regions (a), (b), and (c) are to be data resources in the second and subsequent transmission-scheduled subframes of mapping resource pattern **2**.

Such mapping resource pattern **2** allows reception of data in the second and subsequent transmission-scheduled subframes to be uniform in size, which makes it easier for base station **100** to take the number of resources into consideration for determining an error rate.

Embodiment 3

Embodiment 3 aims at the second object described above. The base station and the terminal according to Embodiment 3 are identical to base station **100** and terminal **200** according to Embodiment 1, respectively, so that a description will be provided with reference to FIGS. **7** and **9**.

In base station **100** according to Embodiment 3, if there are any data signals to be transmitted, transmission controlling section **102** takes, as input, the scheduling identification information outputted from scheduling method determining section **101**. Transmission controlling section **102** determines the "mapping resource pattern" of the control signals and the data signals based on the scheduling identification information and outputs the determined information on the mapping resource pattern to signal scheduling section **106**.

The "mapping resource pattern" for the scheduling identification information indicating SPS has the following configuration in particular:

(1) mapping resource pattern **3** includes N transmission-scheduled subframes (where N is a natural number greater than or equal to two);

(2) in the first transmission-scheduled subframe of mapping resource pattern **3**, region (a), which is described above, is allocated to a mapping resource for DL grant, while regions among PRB pairs to be scheduled by the DL grant, excluding the allocated PRB pair and the PDCCH region, are allocated to the data resource; and

(3) in the second and subsequent transmission-scheduled subframes of mapping resource pattern **3**, the following regions are allocated to the data resource: regions among PRB pairs to be scheduled by the DL grant mapped to region (a) in the first transmission-scheduled subframe excluding the PRB pair set as a search space for the DL grant and PDCCH region.

FIGS. **10**A and **10**B are diagrams provided for describing mapping resource pattern **3**. Specifically, FIGS. **10**A and **10**B illustrate a mapping resource pattern of four PRB pairs to be scheduled by the DL grant residing over two RBGs. As illustrated in FIG. **10**A, region (b) and three regions (c) are allocated to a data resource in the first transmission-scheduled subframe of mapping resource pattern **3**. On the other hand, as illustrated in FIG. **10**B, if the aggregation of the search space for the DL grant is level 2, regions (c) in four PRB pairs to be scheduled by the DL grant excluding the search space for the DL grant is allocated to the data resource in the second and subsequent transmission-scheduled subframes of mapping resource pattern **3**.

In terminal **200** according to Embodiment 3, signal demultiplexing section **202** extracts, from the received signals, a signal component corresponding to the data resource indicated by the information on mapping resource pattern **3** outputted from control-signal receiving section **205** (i.e., signal component corresponding to DL data signals), and outputs the extracted signals to demodulation section **203**.

Such mapping resource pattern **3** enables mapping of UL grant in a PRB pair that is to be scheduled by DL grant in the second and subsequent transmission-scheduled subframes.

If UL grant is to be mapped in the first transmission-scheduled subframe, region (b) may be excluded from the data resource, and the UL grant may be mapped to region (b).

Mapping resource pattern **3** is particularly effective for a search space for UL grant with a high aggregation level. This is because a search space for UL grant with a high aggregation level requires a large number of resources for the scheduling by the UL grant, and thus, the UL grant cannot be assigned if the search space is blocked by the data resource.

Embodiment 4

Embodiment 4 aims at the second object described above. The base station and the terminal according to Embodiment 4 are identical to base station **100** and terminal **200** according to Embodiment 1, respectively, so that a description will be provided with reference to FIGS. **7** and **9**.

In base station **100** according to Embodiment 4, if there are any data signals to be transmitted, transmission controlling section **102** takes, as input, the scheduling identification information outputted from scheduling method determining section **101**. Transmission controlling section **102** determines the "mapping resource pattern" of the control signals and the data signals based on the scheduling identification information and transmits the determined information on the mapping resource pattern to signal scheduling section **106**.

The "mapping resource pattern" for the scheduling identification information indicating SPS has the following configuration in particular:

(1) mapping resource pattern **4** includes N transmission-scheduled subframes (where N is a natural number greater than or equal to two);

(2) in the first transmission-scheduled subframe of mapping resource pattern **4**, region (a), which is described above, is allocated to a mapping resource for the DL grant, while regions (b) and (c) are allocated to data resources (see FIG. **11**A); and

(3) in the second and subsequent transmission-scheduled subframes of mapping resource pattern **4**, only region (c) is allocated to a data resource (see FIG. **11**B).

In terminal **200** according to Embodiment 4, signal demultiplexing section **202** extracts, from the received signals, a signal component corresponding to the data resource indicated by the information on mapping resource pattern **4** outputted from control-signal receiving section **205** (i.e., signal component corresponding to DL data signals) and transmits the extracted signals to demodulation section **203**.

Such mapping resource pattern **4** enables the mapping of UL grant in a PRB pair mapped in the first transmission-scheduled subframe with DL grant in the second and subsequent transmission-scheduled subframes. The UL grant can be mapped to a region other than the PRB that is to be scheduled by the DL grant, and an aggregation level higher than the aggregation level of the DL grant can be configured for the UL grant in such a case. Since the DL grant is mapped to a high channel quality resource, the UL grant can also be mapped to a high quality resource by mapping the DL and UL grants in the same PRB pair. Since the size of PDSCH is supposedly small for VoIP, which often uses SPS transmission, it is effective to multiplex data and the UL grant in the same RBG.

Embodiment 5

Embodiment 5 aims at the first and second objects described above. The base station and the terminal according to Embodiment 5 are identical to base station **100** and terminal **200** according to Embodiment 1, respectively, so that a description will be provided with reference to FIGS. **7** and **9**.

In base station **100** according to Embodiment 5, if there are any data signals to be transmitted, transmission controlling section **102** takes, as input, the scheduling identification information from scheduling method determining section **101**. Transmission controlling section **102** determines the "mapping resource pattern" of the control signals and the data signals based on the scheduling identification information and transmits the determined information on the mapping resource pattern to signal scheduling section **106**.

The "mapping resource pattern" for the scheduling identification information indicating SPS has the following structure in particular:

(1) mapping resource pattern **5** contains N transmission-scheduled subframes (where N is a natural number greater than or equal to two);

(2) in the first transmission-scheduled subframe of mapping resource pattern **5**, region (a), which is described above, is allocated to a mapping resource for the DL grant, while regions (b) and (c) are allocated to data resources (see FIG. **12**A); and

(3) In the second and subsequent transmission-scheduled subframes of mapping resource pattern **4**, regions (a) and (c) are allocated to a data resource (see FIG. **12**B).

In terminal **200** according to Embodiment 5, signal demultiplexing section **202** extracts, from the received signals, a signal component corresponding to the data resource indicated by the information on mapping resource pattern **5** outputted from control-signal receiving section **205** (i.e., signal component corresponding to a DL data signal) and transmits the extracted signal to demodulation section **203**.

Such mapping resource pattern **5** enables the mapping of UL grant in a PRB pair mapped with DL grant in the first transmission-scheduled subframe in the second and subsequent transmission-scheduled subframes. The resource region (region (a), in this case) configured as a control resource in the first transmission-scheduled subframe can be prevented from being left unused in the second and subsequent transmission-scheduled subframes. Since the DL grant is mapped to a high channel quality resource, the UL grant can also be mapped to a high quality resource by mapping the DL and UL grants in the same PRB pair.

OTHER EMBODIMENTS

(1) The mapping resource patterns described in Embodiments 1 to 5 may be switched from one to the other in accordance with the aggregation level of DL grant.

For example, transmission controlling section **102** and signal demultiplexing section **202** can switch between the mapping resource patterns in accordance with the magnitude relationship between the aggregation level of DL grant and the RBG size. Specifically, transmission controlling section **102** and signal demultiplexing section **202** select mapping resource pattern **4** or **5** when the aggregation level of DL grant is smaller than or equal to the RBG size. On the other hand, transmission controlling section **102** and signal demultiplexing section **202** select mapping resource pattern **3** when the aggregation level of DL grant is larger than the RBG size.

Alternatively, transmission controlling section **102** and signal demultiplexing section **202** can switch between the mapping resource patterns in accordance with only the aggregation level of DL grant. Specifically, transmission controlling section **102** and signal demultiplexing section **202** select mapping resource pattern **4** or **5** when the aggregation level of DL grant is 4 or 8. Meanwhile, transmission controlling section **102** and signal demultiplexing section **202** select mapping resource pattern **3** when the aggregation level of DL grant is 1 or 2.

(2) The mapping resource patterns according to Embodiments 1 to 5 can be switched from one to the other based on the resource region in which the UL grant is transmitted. Specifically, transmission controlling section **102** and signal demultiplexing section **202** select mapping resource pattern **1** or **2** when the UL grant transmitted in the PDCCH region. Alternatively, transmission controlling section **102** and signal demultiplexing section **202** select mapping resource pattern **3**, **4**, or **5** when the UL grant is transmitted in the R-PDCCH region. In this case, whether UL grant is transmitted in a PDCCH region or an R-PDCCH region is previously determined.

(3) In the embodiments described above, the R-PDCCH for DL grant may be the actual resource used for the transmission of DL grant to terminal **200**, or the entire search space of DL grant, or include another search space having the same start position but a different aggregation level.

(4) The R-PDCCH according to the embodiments described above may also be referred to as an enhanced PDCCH.

(5) R-PDCCHs are used in an "interleaved" format in which R-PDCCHs for multiple terminals are interleaved and

located on a single PRB, and in a "non-interleaved" format in which only R-PDCCH for a single terminal is located on a single PRB. The mapping resource patterns described in Embodiments 1 to 5 may be applied only to non-interleaved R-PDCCHs,

(6) In the embodiments described above, terminal **200** attempts to detect DL grant for dynamic scheduling and DL grant indicating the termination of SPS in region (a) in all transmission-scheduled subframes. Terminal **200** performs no data transmission according to SPS and gives priority to data transmission according to dynamic scheduling in a transmission-scheduled subframe in which the DL grant for dynamic scheduling is detected. Meanwhile, terminal **200** performs no data transmission according to SPS in transmission-scheduled subframes subsequent to the transmission-scheduled subframe in which the DL grant indicating the termination of SPS is detected.

(7) In the embodiments described above, a description has been given of the case where the scheduling method is employed in which a region in an RBG other than the region to which the DL grant is mapped (i.e., region (a)) is allocated to PDSCH as PDSCH scheduling by DL grant. The claimed invention, however, is not limited to this case, and scheduling method described below may be applied.

<1> PDSCH Scheduling Method **1** by DL Grant

FIGS. **13**A and B are diagrams provided for describing PDSCH scheduling method **1** by DL grant. As illustrated in FIG. **13**A, when a resource allocation bit for the RBG is "1," region (b) is explicitly allocated to a data resource by DL grant. Region (c) is implicitly allocated to a data resource regardless of the value of resource allocation bit. As illustrated in FIG. **13**B, when the resource allocation bit for the RBG is "0," region (c) is allocated to a data resource. In this way, even if UL grant is to be transmitted, PDSCH can be assigned to the RBG in which the DL grant is mapped.

When PDSCH scheduling method **1** is combined with mapping resource patterns **1** to **5**, the mapping resource patterns may need to be modified. Incidentally, mapping resource pattern **2** can be applied in the same way as mapping resource pattern **1** since the only difference therebetween resides in the data resource in the first transmission-scheduled subframe.

When the resource allocation bit is "1," PDSCH scheduling method **1** and mapping resource patterns **1** to **5** can be combined without any modification of the mapping resource patterns.

When the resource allocation bit is "0," the mapping resource patterns may need to be modified. Specifically, when the resource allocation bit is "0," region (b) is not allocated to the data resource in the second and subsequent transmission-scheduled subframes in mapping resource pattern **1**, as illustrated in FIG. **14**B. Specifically, regions (a) and (c) are allocated to the data resources in the second and subsequent transmission-scheduled subframes.

Even when the resource allocation bit is "0," mapping resource patterns **3**, **4**, and **5** can be applied in the same way as in the case where the resource allocation bit is "1."

<2> PDSCH Scheduling Method **2** by DL Grant

PDSCH scheduling method **2** by DL grant differs from PDSCH scheduling method **1** by DL grant in that no region (c) is allocated to a data resource (see FIGS. **15**A and B).

When PDSCH scheduling **2** is combined with mapping resource patterns **1** to **5**, the mapping resource patterns may need to be modified. Even when the resource allocation bit is "1," the mapping resource patterns may need to be corrected. There is no combination of PDSCH scheduling method **2** with mapping resource pattern **4**, however.

Specifically, when the resource allocation bit is "1," regions (a) and (b) are allocated to the data resources in the second and subsequent transmission-scheduled subframes while region (c) is not allocated to a data resource in mapping resource pattern **1**, as illustrated in FIG. **16**B. Mapping resource pattern **2** can be applied in the same way as mapping resource pattern **1** since the only difference therebetween resides in the data resource in the first transmission-scheduled subframe.

When the resource allocation bit is "1," no modification is required in the second and subsequent transmission-scheduled subframes in mapping resource pattern **3**.

When the resource allocation bit is "1," only region (b) is allocated to the data resource in the first transmission-scheduled subframe in mapping resource pattern **5**, as illustrated in FIG. **17**A, while only region (a) is allocated to the data resources in the second and subsequent transmission-scheduled subframes, as illustrated in FIG. **17**B.

<3> PDSCH Scheduling Method **3** by DL Grant

PDSCH scheduling method **3** by DL grant differs from PDSCH scheduling **2** method by DL grant in that only region (c) is allocated to the data resource when resource allocation bit is "1" (see FIG. **18**A).

When the resource allocation bit is "1," PDSCH scheduling method **3** by DL grant can be applied in the same way as the case where the resource allocation bit is "0" in PDSCH scheduling method **1** by DL grant.

<4> PDSCH Scheduling Method **4** by DL Grant

Region (c) is divided into a first slot region (c-1) and a second slot region (c-2) in PDSCH scheduling method **4**.

FIGS. **19**A and B are provided for describing PDSCH scheduling method **4** by DL grant. As illustrated in FIG. **19**A, regions (b) and (c-2) are allocated to the data resource by the DL grant when the resource allocation bit is "1." As illustrated in FIG. **19**B, when the resource allocation bit is "0," PDSCH scheduling method **4** is applied in the same way as PDSCH scheduling method **2** by DL grant.

When PDSCH scheduling method **4** is combined with mapping resource patterns **1** to **5**, the mapping resource patterns may need to be modified. Even when the resource allocation bit is "1," the mapping resource patterns may need to be modified.

Specifically, when the resource allocation bit is "1," mapping resource pattern **1** is the same as the mapping resource pattern according to Embodiment 1, except that region (c-1) is excluded from the data resource, as illustrated in FIGS. **20**A and B.

When the resource allocation bit is "1," mapping resource pattern **4** is the same as the mapping resource pattern according to Embodiment 4, except that region (c-1) is excluded from the data resource, as illustrated in FIGS. **21**A and B.

When the resource allocation bit is "1," mapping resource pattern **5** is the same as the mapping resource pattern according to Embodiment 5, except that region (c-1) is excluded from the data resource, as illustrated in FIGS. **22**A and B.

<5> PDSCH Scheduling Method **5** by DL Grant

In PDSCH scheduling method **5**, DL grant is located over a plurality of adjacent PRBs, as illustrated in FIGS. **23**A and B. Thus, region (b) includes a plurality of sub-regions in PRB units. The UL grant is mapped to part of the sub-regions. That is, in PDSCH scheduling **5**, the search space of DL grant differs from the search space of UL grant.

FIGS. **23**A and B are diagrams provided for describing PDSCH scheduling method **5** by DL grant. As illustrated in FIG. **23**A, when the resource allocation bit is "1," regions (b-2) and (c) to which no UL grant is mapped by the DL grant are allocated to data resources. Meanwhile, as illustrated in

FIG. 23B, when the resource allocation bit is "0," all regions (a), (b), and (c) are excluded from the data resources.

When PDSCH scheduling method **5** is combined with mapping resource patterns **1** to **5**, the mapping resource patterns may need to be modified. Even when the resource allocation bit is "1," the mapping resource patterns may need to be modified. PDSCH scheduling method **5** is not combined with mapping resource pattern **4** or **5**.

Specifically, when the resource allocation bit is "1," regions (b-2) and (c) are allocated to the data resources in the first transmission-scheduled subframe in mapping resource pattern **1**, as illustrated in FIG. **24**A. In this case, regions (b-2) and (c), in addition to region (a), are allocated to the data resources in the second and subsequent transmission-scheduled subframes in mapping resource pattern **1**, as illustrated in FIG. **24**B. Mapping resource pattern **2** can be applied in the same way as mapping resource pattern **1** since the only difference therebetween resides in the data resource in the first transmission-scheduled subframe.

When the resource allocation bit is "1," no modification is required in the second and subsequent transmission-scheduled subframes in mapping resource pattern **3**.

[8] In the embodiments described above, DL grant is mapped in the first slot, and UL grant is mapped in the second slot. That is, the resource to which the DL grant is mapped is separated from the resource to which the UL grant is mapped in the time domain. The claimed invention, however, it not limited thereto, and the resource to which the DL grant is mapped may be separated from the resource to which the UL grant is mapped in the frequency domain (i.e., subcarriers or PRB pairs).

<1> PDSCH Scheduling Method **6** by DL Grant

FIGS. **25**A and B are provided for describing PDSCH scheduling method **6**. As illustrated in FIG. **25**A, the plurality of subcarriers of the allocated PRB are divided into two subcarrier blocks. One of the two subcarrier blocks corresponds to region (a) to which DL grant is mapped. The other subcarrier block of the two subcarrier blocks corresponds to region (b) to which UL grant is mapped.

When the resource allocation bit is "1" in PDSCH scheduling method **6**, region (c) is allocated to the data resource, as illustrated in FIG. **25**A, whereas region (c) is not allocated to the data resource when the resource allocation bit is "0" as illustrated in FIG. **25**B.

In a case where mapping resource pattern **1** is applied to PDSCH scheduling method **6**, the first transmission-scheduled subframe corresponds to the state of the first transmission-scheduled subframe illustrated in FIG. **26**A, and the second and subsequent transmission-scheduled subframes correspond to the state of the second and subsequent transmission-scheduled subframes illustrated in FIG. **26**B.

<2> PDSCH Scheduling Method **7** by DL Grant

FIGS. **27**A and B are diagrams provided for describing PDSCH scheduling method **7**. As illustrated in FIG. **27**A, the DL grant is mapped to region (a) other than the PDCCH region in one PRB pair. The DL grant allocates regions (b) and (c) other than the PDCCH region in the other two PRB pairs to data resources.

When the resource allocation bit is "1" in PDSCH scheduling method **7**, regions (b) and (c) are allocated to the data resources as illustrated in FIG. **27**A, whereas when the resource allocation bit is "0," the UL grant is mapped to region (b) as illustrated in FIG. **27**B. In such a case, region (c) is not allocated to a data resource.

When mapping resource pattern **1** is applied to PDSCH scheduling **7**, the first transmission-scheduled subframe corresponds to the state of the first transmission-scheduled subframe illustrated in FIG. **28**A, and the second and subsequent transmission-scheduled subframes correspond to the state of the second and subsequent transmission-scheduled subframes illustrated in FIG. **28**B.

When mapping resource pattern **3** is applied to PDSCH scheduling method **7**, the first transmission-scheduled subframe corresponds to the state of the first transmission-scheduled subframe illustrated in FIG. **29**A, and the second and subsequent transmission-scheduled subframes correspond to the state of the second and subsequent transmission-scheduled subframes illustrated in FIG. **29**B. More specifically, the resources other than the search space for UL grant (i.e., regions (a) and (c) in FIG. **29**B) are allocated to the data resources in the second and subsequent transmission-scheduled subframes.

The embodiments of the claimed invention described above are provided as hardware. The claimed invention can be achieved through software in cooperation with hardware.

The functional blocks described in the embodiments are achieved by an LSI, which is typically an integrated circuit. The functional blocks may be provided as individual chips, or part or all of the functional blocks may be provided as a single chip. Depending on the level of integration, the LSI may be referred to as an IC, a system LSI, a super LSI, or an ultra LSI.

In addition, the circuit integration is not limited to LSI and may be achieved by dedicated circuitry or a general-purpose processor other than an LSI. After fabrication of LSI, a field programmable gate array (FPGA), which is programmable, or a reconfigurable processor which allows reconfiguration of connections and settings of circuit cells in LSI may be used.

Should a circuit integration technology replacing LSI appear as a result of advancements in semiconductor technology or other technologies derived from the technology, the functional blocks could be integrated using such a technology. Another possibility is the application of biotechnology and/or the like.

The disclosure of Japanese Patent Application No. 2011-077943, filed on Mar. 31, 2011, including the specification, drawings and abstract, is incorporated herein by reference in its entirety.

INDUSTRIAL APPLICABILITY

The transmission apparatus, the reception apparatus, the transmission method, and the reception method according to the claimed invention are useful in that they enable transmission of a series of data while the data is distributed to data resources in N transmission subframes (where N is a natural number greater than or equal to two) when control signals are transmitted in a resource region usable for a control channel or data channel.

REFERENCE SIGNS LIST

100 Base station
101 Scheduling method determining section
102 Transmission controlling section
103 Control-signal generating section
104, **206** Error-correction coding section
105, **207** Modulation section
106, **208** Signal scheduling section
107, **209** Radio transmitting section
108, **201** Radio receiving section
109, **203** Demodulation section
110, **204** Error-correction decoding section
200 Terminal
202 Signal demultiplexing section
205 Control-signal receiving section

The invention claimed is:

1. A transmission apparatus that maps control signals for a reception apparatus to a first resource region usable for a control channel or a data channel or to a second resource region usable for a control channel, transmits the mapped signals, and transmits a series of data to the reception apparatus while distributing the series of data to data resources in N transmission subframes to be transmitted consecutively with a predetermined frame interval therebetween, where N is a natural number greater than or equal to two, the transmission apparatus comprising:

a generating section that generates scheduling control signals for the data resources;

a setting section that sets the data resources, and a control resource region to which the scheduling control signals are mapped in the first resource region in a resource block group (RBG); and

a mapping section that maps the series of data to the set data resources and maps the scheduling control signals to the control resource region, wherein

the setting section sets resource regions in the N transmission subframes such that the setting section sets the first resource region as the control resource region in the first transmission subframe of the N transmission subframes and sets the first resource region as the data resource in each of second to Nth transmission subframes subsequent to the first transmission subframe,

the RBG is formed of M resource blocks (RBs), M being a natural number greater than or equal to two, and the RBG is common between the N transmission subframes, and

the mapping section maps a downlink grant as the scheduling control signals to the first resource region set as the control resource region in the first transmission subframe, and maps downlink data to the first resource region set as the data resource in each of the second to Nth transmission subframes.

2. The transmission apparatus according to claim 1, wherein,

the region of the RBG other than the second resource region includes a first region set as the control resource region in the first transmission subframe, a second region other than the first region in RBs including the first region, and a third region formed of RBs other than RBs including the first and second regions, and

the setting section further sets the third region as the data resources in all of the N transmission subframes.

3. The transmission apparatus according to claim 2, wherein,

the setting section sets the second and third regions as the data resources in the first transmission subframe, and

the setting section sets all of the first, second, and third regions as the data resources in the transmission subframes except for the first transmission subframe.

4. The transmission apparatus according to claim 2, wherein,

the setting section sets the second and third regions as the data resources in the first transmission subframe, and

the setting section sets the first and third regions, but not the second region, as the data resources in the transmission subframes except for the first transmission subframe.

5. A reception apparatus that receives reception signals including control signals transmitted from a transmission apparatus through a first resource region usable for a control channel or a data channel or a second resource region usable for a control channel and receives a series of data being transmitted from the transmission apparatus while being distributed to data resources in N transmission subframes transmitted consecutively with a predetermined frame interval therebetween, where N is a natural number greater than or equal to two, the reception apparatus comprising:

a detecting section that detects scheduling control signals for the data resources included in the reception signals; and

an extracting section that extracts, from the reception signals, a signal component in a data-component extraction target region corresponding to the data resource in a resource block group (RBG), wherein

the extracting section treats resource regions in the N transmission subframes such that the extracting section treats, when a downlink grant mapped as the scheduling control signals are detected in the first resource region in the first transmission subframe of the N transmission subframes, the first resource region as the data-component extraction target region in each of second to Nth transmission subframes subsequent to the first transmission subframe to extract downlink data mapped in each of the second to Nth transmission subframes, and

the RBG is formed of M resource blocks (RBs) including an RB in which the scheduling control signals are detected, M being a natural number greater than or equal to two, and the RBG is common between the N transmission subframes.

6. The reception apparatus according to claim 5, wherein,

the region of the RBG other than the second resource region includes a first region in which the scheduling control signals are detected in the first transmission subframe, a second region other than the first region in RBs including the first region, and a third region formed of RBs other than RBs including the first and second regions, and

the extracting section further treats the third region in all the N transmission subframes as the data-component extraction target region.

7. The reception apparatus according to claim 6, wherein,

the extracting section treats the second and third regions as the data-component extraction target region in the first transmission subframe, and

the extracting section treats all of the first, second, and third regions as the data-component extraction target region in the transmission subframes except for the first transmission subframe.

8. The reception apparatus according to claim 6, wherein,

the extracting section treats the second and third regions as the data-component extraction target region in the first transmission subframe, and

the extracting section treats the first and third regions, but not the second region, as the data-component extraction target region in the transmission subframes except for the first transmission subframe.

9. A transmission method of mapping control signals for a reception apparatus in a first resource region usable for a control channel or a data channel or in a second resource region usable for a control channel, transmitting the mapped signals, and transmitting a series of data to the reception apparatus while distributing the series of data to data resources in N transmission subframes to be transmitted consecutively with a predetermined frame interval therebetween, where N is a natural number greater than or equal to two, the method comprising:

generating scheduling control signals for the data resources;

setting the data resources, and a control resource region to which the scheduling control signals are mapped in the first resource region in a resource block group (RBG); and

mapping the series of data to the set data resources and mapping the scheduling control signals to the control resource region, wherein

resource regions are set in the N transmission subframes such that the first resource region is set as the control resource region in the first transmission subframe of the N transmission subframes and the first resource region is set as the data resources in each of second to Nth transmission subframes subsequent to the first transmission subframe, wherein

the RBG is formed of M resource blocks (RBs), M being a natural number greater than or equal to two, and the RBG is common between the N transmission subframes, and wherein

a downlink grant as the scheduling control signals is mapped to the first resource region set as the control resource region in the first transmission subframe, and downlink data are mapped to the first resource region set as the data resource in each of the second to Nth transmission subframes.

10. A reception method of receiving reception signals including control signals transmitted from a transmission apparatus through a first resource region usable for a control channel or a data channel or a second resource region usable for a control channel and receiving a series of data being transmitted from transmission apparatus while being distributed to data resources in N transmission subframes transmitted consecutively with a predetermined frame interval therebetween, where N is a natural number greater than or equal to two, the method comprising:

detecting scheduling control signals for the data resources included in the reception signals; and

extracting, from the reception signals, a signal component in a data-component extraction target region corresponding to the data resources in a resource block group (RBG), wherein

resource regions are treated in the N transmission subframes such that, when a downlink grant mapped as the scheduling control signals are detected in the first resource region in the first transmission subframe of the N transmission subframes, the first resource region is treated as the data-component extraction target region in each of second to Nth transmission subframes subsequent to the first transmission subframe to extract downlink data mapped in each of the second to Nth transmission subframes, and

the RBG is formed of M resource blocks (RBs) including an RB in which the scheduling control signals are detected, M being a natural number greater than or equal to two, and the RBG is common between the N transmission subframes.

11. The transmission method according to claim **9**, wherein,

the region of the RBG other than the second resource region includes a first region set as the control resource region in the first transmission subframe, a second region other than the first region in RBs including the first region, and a third region formed of RBs other than RBs including the first and second regions, and further comprising:

setting the third region as the data resources in all of the N transmission subframes.

12. The transmission method according to claim **11**, further comprising:

setting the second and third regions as the data resources in the first transmission subframe, and

setting all of the first, second, and third regions as the data resources in the transmission subframes except for the first transmission subframe.

13. The transmission method according to claim **11**, further comprising:

setting the second and third regions as the data resources in the first transmission subframe, and

setting the first and third regions, but not the second region, as the data resources in the transmission subframes except for the first transmission subframe.

14. The reception method according to claim **10**, wherein,

the region of the RBG other than the second resource region includes a first region in which the scheduling control signals are detected in the first transmission subframe, a second region other than the first region in RBs including the first region, and a third region formed of RBs other than RBs including the first and second regions, and further comprising:

treating the third region in all the N transmission subframes as the data-component extraction target region.

15. The reception method according to claim **14**, further comprising:

treating the second and third regions as the data-component extraction target region in the first transmission subframe, and

treating all of the first, second, and third regions as the data-component extraction target region in the transmission subframes except for the first transmission subframe.

16. The reception method according to claim **14**, further comprising:

treating the second and third regions as the data-component extraction target region in the first transmission subframe, and

treating the first and third regions, but not the second region, as the data-component extraction target region in the transmission subframes except for the first transmission subframe.

* * * * *